Final Report RSC-3380

LANDSAT/COASTAL PROCESSES

Wesley P. James
John M. Hill
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TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

107

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ABSTRACT

The purpose of this research program was to evaluate the use of Landsat imagery to quantitatively monitor turbidity and color in coastal waters. Satellite imagery was obtained and water quality parameters were measured off Tampa, Florida for three dates in 1976. Water quality data were obtained at twenty stations ranging from two to sixty nautical miles offshore.

Since the incident lighting of the sea and light path radiance varied for each date, data from each sampling trip were analyzed separately. Satellite radiance values correlated well with water color, Secchi disk depth, turbidity, and attenuation coefficients.

It is concluded that satellite imagery is potentially useful for quantitative evaluation of certain optical properties of the ocean and for optical classification of ocean and coastal waters. It is strongly recommended that NASA develop the methodology whereby scientists and engineers can convert satellite imagery into conventional optical water quality values without field sampling at the time of each individual overpass.

ACKNOWLEDGEMENT

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INTRODUCTION

The detection of water masses is fundamental to the study of marine processes. Multispectral scanners on Landsat 1 and 2 have been utilized to investigate such features as outfalls, river plumes, fisheries, currents, pollution, sediments, and turbidity.

Remotely imaged data are limited in perceptual capabilities to the upper part of the water column. It is this layer that is of most direct concern to mankind due to tidal fluctuations, shoaling, and currents, as well as being the zone that composes harbors, shorelines, and estuaries. This zone also supports photosynthesis, the base of food chains in the sea (6). Man may disturb the natural condition of this superficial layer by such activities as dredge and fill operations, boating, polluting, channelization of rivers, and urbanization of lands adjacent to rivers with subsequent increased runoff.

Erosion in drainage basins is generally increased when natural vegetation is removed. Exposed, unprotected soil is more susceptible to erosion which results in higher concentration of soil particles in the runoff.

Sediment particles transported with the runoff may have public health implications because viruses, bacteria, and electrically charged chemicals tend to adsorb on particular surfaces (17). These pollutants may potentially affect

estuarine and coastal marine life. Increased turbidity levels resulting from elevated suspended sediment concentrations and/or dissolved organic materials can decrease the amount of light reaching marine organisms resulting in decreased photosynthetic activity. The siltation that tends to accompany turbidity may kill benthic organisms and destroy highly productive grass flats (13). Suspended sediment concentration is considered an important water quality parameter. The U.S. Geological Survey has initiated a data collection network to monitor suspended sediment levels in major streams (16).

Objectives

The purpose of this research program is to evaluate the use of Landsat to quantitatively monitor turbidity and color in coastal waters. Specific objectives are to: (1) classify sampling sites in the Tampa, Florida area according to radiance values of the four spectral bands of Landsat satellites and (2) correlate Landsat radiance values to optical properties of the water.

Description of Landsat 1 and 2

Landsat 1 (formerly denoted as ERTS-1) was launched on July 23, 1972, and was accompanied by Landsat 2 on January 22, 1975. At the time this study was conducted the two

satellites were synchronized to pass over any particular point on the earth's surface every nine days. Each satellite operates in a circular, sun-synchronous, near-polar orbit at an altitude of approximately 920 km. Every twenty-four hours each Landsat satellite completes fourteen orbits (15).

The Landsat Multispectral Scanner (MSS) is a line scanning device that utilizes an oscillating mirror to continously scan perpendicular to the spacecraft track. Six lines are scanned simultaneously in each of the four spectral bands for each mirror sweep. The four bands consist of spectral bands from 500 nm to 1100 nm (500-600 nm, 600-700 nm, 700-800 nm, and 800-1100 nm). The MSS continually scans the earth in a 185.2 km swath perpendicular to the Landsat orbital track. Satellite motion provides the along-track progression of the scan lines. Nominal instantaneous field of view of each detector is 57 by 79 meters.

LITERATURE REVIEW

Several investigators have attempted to correlate radiance values with suspended solids as opposed to correlating radiance values with turbidity levels. Attempts to quantify turbidity have led to a proliferation of definitions, units of measure, and instruments. Turbidity data for natural waters are applied to several uses, including: (1) determination of the depth to which photosynthesis can occur, (2) aesthetic evaluation of water, and (3) estimation of concentration of suspended material. Lack of standardization of the measurement often has resulted in correlations between unrelated numbers.

Turbidity was originally defined as an optical measurement of the concentration of suspended solids (6). It was soon found that turbidity did not always give the same values of suspended solids as did other methods. McCluney (13) found nine definitions of turbidity in a search of the literature and classified them into two groups: those based on comparison with standard suspensions of known turbidities and those based on the absolute measurement of an optical quantity. McCluney, although favoring the use of transmittance meters, which measure an optical property of a medium, stated that devices such as the Hach turbidimeter, which are based on the scattering of white light at right angles to the incident beam, will continue to be commonly used to derive turbidity values.

Definitions

Few water quality characteristics of natural waters are more difficult to explain quantitatively than is the phenomenon of turbidity. Attempts to quantify turbidity have resulted in a large number of methods, standards, and units of measure. A listing of some current definitions of turbidity is given.

(1) Turbidity and nephelometry are based on the attenuation due to scattering by particles.

  (A) "Turbidity is a measurement made of the intensity of light transmitted through the medium, i.e., of the unscattered light."

  (B) "Nephelometry is the intensity of the scattered light measured usually, but not necessarily, at right angles to the incident light beam."

(2) "In physical chemistry research, turbidity is expressed as a ratio of the intensity of light scattered by a unit volume of the sample to the intensity of the incident light illuminating the sample. This is known as either its Rayleigh ratio or the scattering coefficient and is designated as R_{90} when the light scattered at 90° to the transmitted beam of light is considered."

(3) According to Standard Methods (19), "turbidity should be clearly understood to be an expression of the optical

property of a sample which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample."

(4) The following definitions are given by the American Society for the Testing of Materials (ASTM) (1).

(A) Turbidity, in general, is the reduction of transparency of a sample due to the presence of particulate matters.

(B) Jackson candle turbidity is an empirical measure of turbidity in special apparatus, based on the depth of water in a column that is sufficient to extinguish the image of a burning standard candle observed vertically through the sample.

(C) Nephelometric turbidity is an empirical measure of turbidity based on the light scattering characteristics of the particulate matter in the sample.

(D) Absolute turbidity is the fractional decrease of incident monochromatic light through the sample integrating both scattered and transmitted light.

(5) A Hach turbidimeter measures turbidity based on the scattering of white light at right angles to the incident beam, giving readings in Formazin turbidity units (FTU). The instrument is calibrated with a set of permanent turbidity standards that simulate the Formazin suspensions.

It is generally concluded that too many factors must remain constant (a condition rare in coastal waters) before a turbidity measurement may be directly and accurately converted to a suspended sediment concentration. However, if the shape, surface consistency, composition, and colors of suspended particles is constant, it may be possible to infer the amount of suspended matter in natural waters.

Previous Investigations

Important fisheries information related to turbidity has been derived from Landsat data. Maughan (12) showed that areas exhibiting turbidity in shoal water tended to be areas previously known to be centers of fishing activity. In this situation Landsat could be a useful predictive tool by providing significant information for the harvesting of menhaden schools. These schools were located in areas of lowest Landsat band 5 image density. Kemmerer and Butler (8) have shown that there are relationships between the distribution of menhaden and water color. From water color differences sensed by Landsat, inferences as to the probable presence or absence of menhaden have been made.

There has been much interest in the possibility of remotely detecting turbidity levels. Clark (4) has attempted to derive coastal water classifications via spectral signatures from Landsat 1 MSS data. He found that radiances

can be used to identify and map the major water masses in the New York Bight. Optical properties of water were shown to be extremely sensitive to changes in numbers, composition, and size distribution of suspended materials.

Landsat bands 4 and 5 are generally accepted as being the best for turbidity investigations. Based on the pure water spectral attenuation coefficient, the best correlation would be expected in the green band (MSS 4). In a study of Kansas reservoirs, Yarger (21) found that the green band exhibited strong correlations with suspended load and sunlight penetration depth but was more sensitive to atmospheric conditions than the red band. Although there appears to be a good qualitative correlation between red reflectance (MSS 5) and turbidity, Scherz (18) shows that the correlation of suspended solids with turbidity is not universal but varies for different waters. For example, it is possible to have a few large particles of brown material which scatter considerably less energy than a large number of fine white particles of the same weight. There may be a correlation between the weight of suspended material and turbidity, but this correlation will not necessarily hold for another material in a different type of water.

Several investigators have related suspended sediments with reflected radiation. These studies have been mainly in bays on the east coast of the United States. Williamson and

Grabau (20) studied several rivers in the Chesapeake Bay. Kritikos (10) analyzed Landsat data of the Potomac River but did not relate the radiances to numerical values of in-situ suspended material.

Klemas (9) obtained data from the Delaware Bay on July 7, 1973. On the basis of only four sediment concentrations collected simultaneously with a single Landsat overpass, a relation was computed between measured concentration values and radiance in MSS Band 5 using a non-linear regression:

$$y = ae^{bx}$$

where:

y = sediment concentration (mg/l)

x = radiance (mw/cm^2)

a = 1.169

b = 8.481

The correlation coefficient was 0.99598 but was based on only four data points. From this relation, the predicted sediment concentrations ranged from 5.6 mg/l to 211 mg/l.

Johnson (7) made quantitative assessments of suspended sediments from aircraft remotely sensed multispectral data. Remotely sensed data were collected by an 11-band (10-bands in the visible and near IR and 1 thermal band) Bendix Modular Multispectral Scanner from a flight altitude of 8000 feet. Ground truth measurements were made at three sites in

the tidal James River, Virginia. For suspended sediment concentrations up to 50 mg/l, a single band (700-740 nm) gave a correlation coefficient of 0.89 with a standard error of 4.8 mg/l at an average sediment concentration of 20.3 mg/l for forty-five water samples. The correlation coefficient increased from 0.89 to 0.93 with a standard error of 4.3 mg/l when radiance values from ten channels were used in the linear regression analysis. Figure 1 displays relationships derived by aforementioned investigators. Differences in the relationships could be due to variations in particle size distribution, particle color, water color, and sediment concentration from one area to another. These factors determine the spectral characteristics of a water type. Johnson has indicated the need for additional remotely sensed data in conjunction with water sampling to additionally define the accuracy of regression equations for quantitative analysis of digital multispectral data.

Williamson and Grabau (20) have utilized Landsat 2 imagery of the Chesapeake Bay and York River to convert a reflectance spectrum as measured by Landsat into a concentration of suspended sediment. These investigators realized the need to "correct" Landsat spectra for the effect of the atmosphere. Due to the inability to correct reliable near-ground spectral data, they had to utilize a much less satisfying procedure. This scheme included back-calculating from

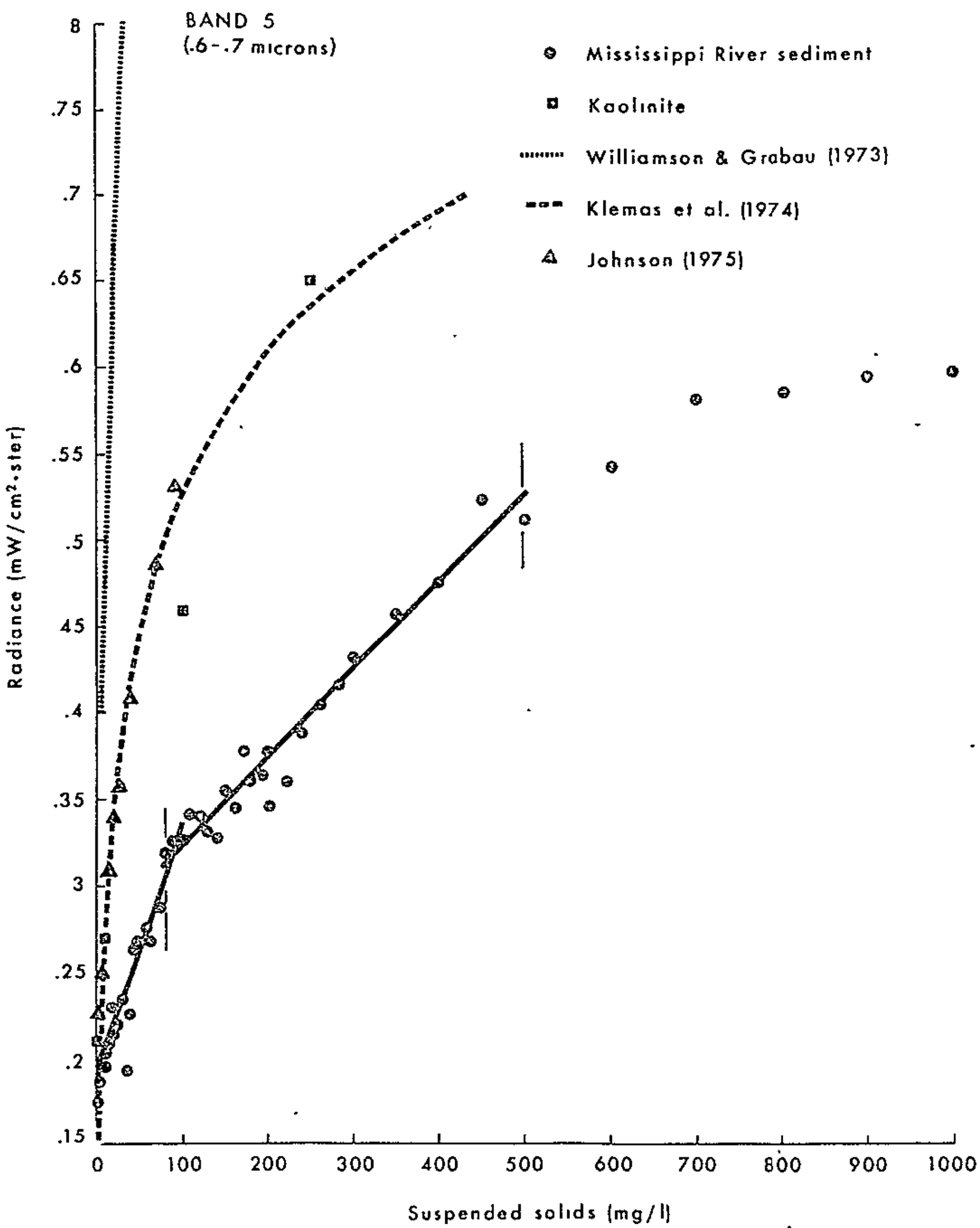


Fig. 1. Suspended sediment concentration versus radiance for wavelengths of 600 to 700 nanometers(Landsat band 5).

the NASA tapes' values to obtain predictions of near-ground radiance spectra. This was done using NASA-provided data on gain settings (M_i), and atmospheric transmittance values obtained by manipulating the Air Force Cambridge Research Laboratories (AFCRL) atmospheric effects model (Equation 1).

$$H = \frac{X \cdot M_i}{63 \cdot T_i} \qquad (1)$$

where H = Radiance in mw/cm^2 - SR

X = Value from Landsat digital imagery

M_i = Gain setting (from NASA)

T_i = Atmospheric Transmittance (from AFCRL Model)

$M_1 = 2.48$	$T_1 = 0.69$
$M_2 = 2.00$	$T_2 = 0.75$
$M_3 = 1.76$	$T_3 = 0.63$
$M_4 = 4.60$	$T_4 = 0.76$

In theory, this equation gives the spectrum that would be read by a near-ground radiometer, according to Williamson and Grabau. Although this equation was not validated, radiance values used in their study were obtained in this way.

METHODS AND PROCEDURES

Description of Study Area

The study area for this research is the water off Tampa Bay, Florida (see Figures 2 and 3). The research was conducted from the Texas Clipper, a 475-foot vessel operated by the Maritime Academy of Texas A&M University and was one phase of the cruise which began June 6, 1976 and terminated August 1, 1976. Continuous water quality measurements were collected both day and night for the entire cruise which extended along the Gulf of Mexico and the eastern seaboard of the United States. The interim report contains all of the raw water quality data collected aboard the Texas Clipper as well as a description of sample collection and analysis procedures. During the entire cruise Landsat imagery was available only from the Tampa Bay area. Supplemental water quality data were provided by the Florida Department of Natural Resources and the Mote Marine Laboratories.

Water Quality Data

Description of the water quality data collection effort by the Texas Clipper is contained in "Landsat/Coastal Processes, Interim Report RSC-3380," submitted to GSFC November 1,

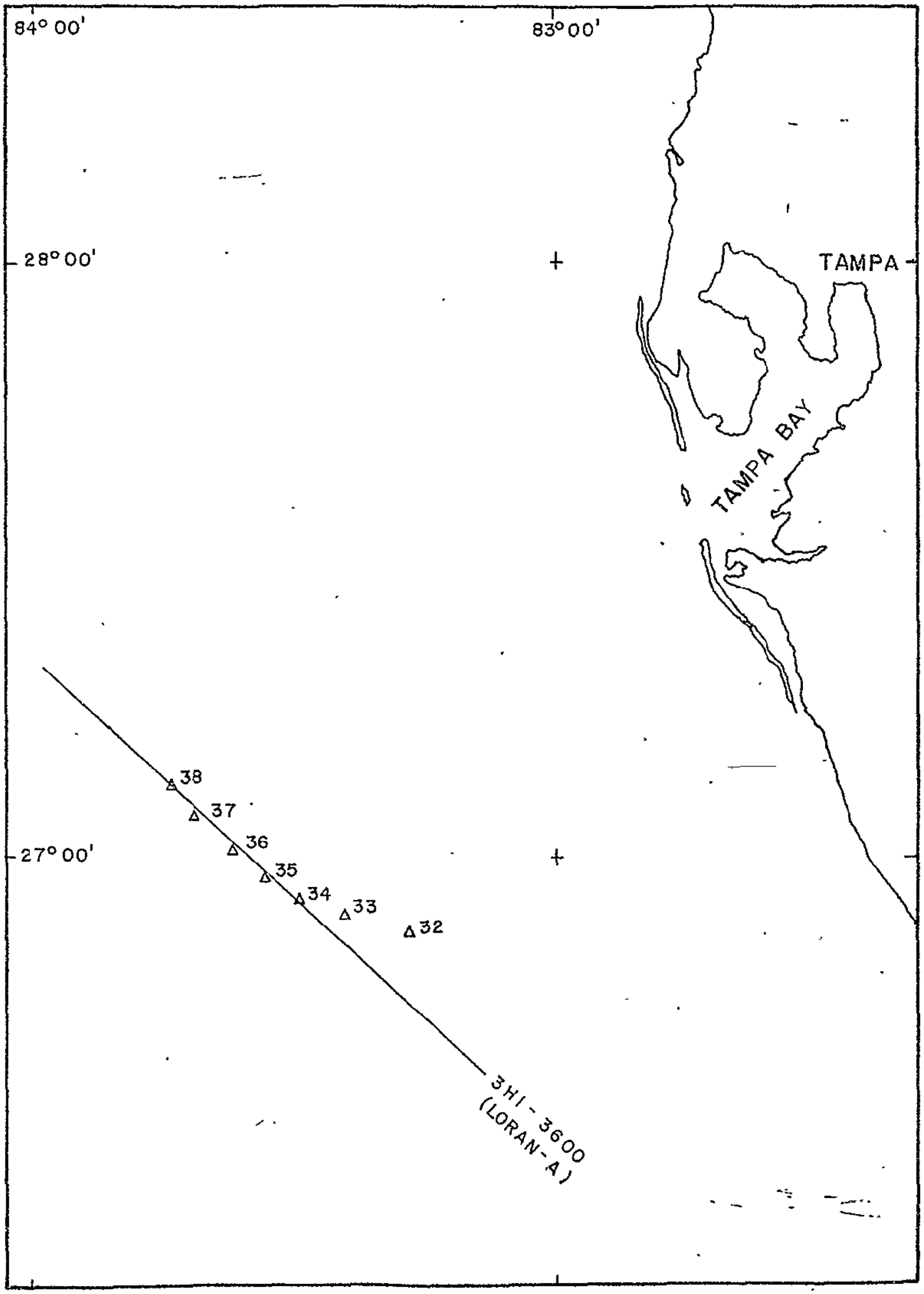


Fig. 2. Texas Clipper Sampling Stations off Tampa, Florida, July 21, 1976 (From C & GS 11006).

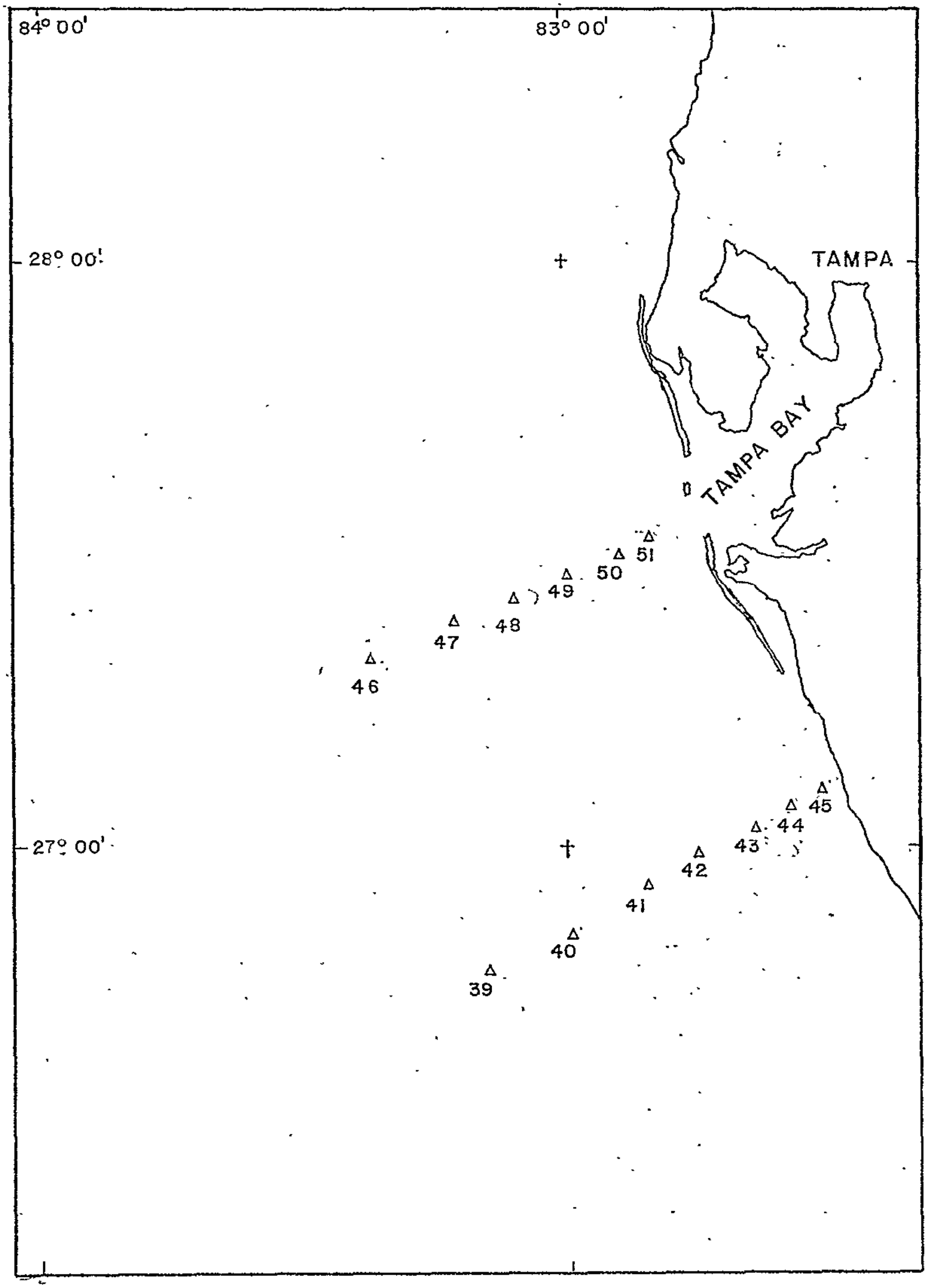


Fig. 3. Stations sampled by Mote Marine Labs(39-45) and by FDNR(46-51).

1976. Water quality samples were collected at seven stations in the Tampa Bay area (Figure 2). Positions for these stations are given in Table 1. Data utilized in this study included turbidity and suspended solids measurements, as well as Secchi disk and submersible photometer measurements. Measurements were taken between the hours of approximately 8:00 a.m. and 2:00 p.m. on July 21, 1976, so as to bracket the time (1115 EDT, 1515 GCT) of the Landsat overpass of the area.

Supplemental water truth data collected by the Florida Department of Natural Resources (FDNR), St. Petersburg, and by Mote Marine Laboratories, Sarasota, Florida were obtained. These data were collected on two dates in 1975 and two dates in 1976. Computer compatible tapes (CCT) were requested and obtained from GSFC for two dates in 1975 and two dates in 1976. Images for the two dates in 1975 contained extensive cloud cover and were of comparatively low image quality. The images for the two dates in 1976 were in the high gain mode and image quality was good. Water quality parameters were measured on February 28, 1976 and March 26, 1976 by FDNR and by Mote Marine Laboratories. Measurements at stations 39-45 were obtained by Mote Marine Laboratories and stations 46-51 were sampled by FDNR (Figure 3). Positions for stations 39-51 are found in Table 2. Sampling site

TABLE 1

Time and Position Data, Stations 32-38,
July 21, 1976

Station Number	Time CGT	Position ϕ	Position λ	Distance Offshore (Naut. miles)
32	1200	26° 51.5'	83° 16.5'	60
33	1300	26° 54.2'	83° 26.0'	
34	1330	26° 55.4'	83° 30.0'	
35	1430	26° 57.9'	83° 33.8'	
36	1530	27° 00.0'	83° 37.5'	
37	1645	27° 03.5'	83° 42.0'	
38	1800	27° 07.7'	83° 45.0'	

TABLE 2.

Position Data: Stations 39 - 51

Station Number	Position ϕ	λ	Distance Offshore (miles)
39	26° 52.0'	83° 09.0'	40
40	26° 57.5'	82° 59.5'	30
41	27° 02.5'	82° 50.0'	20
42	27° 05.0'	82° 45.0'	15
43	27° 07.5'	82° 40.5'	10
44	27° 10.0'	82° 35.5'	5
45	27° 11.5'	82° 33.0'	2
46	27° 22.8'	83° 22.4'	40
47	27° 25.9'	83° 13.4'	30
48	27° 28.9'	83° 04.2'	20
49	27° 30.3'	82° 59.5'	15
50	27° 31.8'	82° 55.0'	10
51	27° 33.2'	82° 50.4'	4

positions are essentially identical for the two dates, February 28 and March 20, 1976. Data were also obtained on July 21, 1976 by FDNR but was of no use for this study due to cloud cover in their sampling area.

Satellite radiance values and water quality parameters are presented in Tables 3, 4, and 5. Turbidity was measured by a Hach turbidimeter and suspended solids determined according to procedures outlined in Standard Methods (19). Secchi visibility on July 21 was determined by lowering a 30 cm white Secchi disk over the side of a lifeboat.

Photometer Data

A multichannel submarine photometer was used to obtain a series of underwater measurements at seven stations off Tampa on July 21, 1976. The physical size of the ship (485 feet in length) precluded its use as a platform for measurements and a lifeboat (25 feet in length) was used as the platform for making the photometer measurements.

The submarine photometer, Model No. 268WA360 Kahlsico Universal Radiometric Submarine Photometer, consists of a deck control unit and two sensing cells, a deck cell and a sea cell. The deck cell remained on the lifeboat and the sea cell was deployed from the lifeboat via a 200-foot cable. Both sea and deck cells contain four small photosensors, each with a different spectral response; two positions had filters that matched the bandwidth of Landsat 4

(green) and band 5 (red), one position contained a blue color filter, and the fourth sensor is without any filter. Readings were made at depths of five, ten, fifteen, twenty, and twenty-five fathoms. Depth at the stations ranged from twenty-nine to thirty fathoms. The photometer measures the volume-integrated loss of energy as a function of water depth providing data for the computation of attenuation coefficients. The radiance values computed from the photometer readings (see Interim Report) are listed in Table 6 and near-surface attenuation coefficients are listed in Table 5.

TABLE 3

Water Quality Parameters, February 28, 1976

Station Number	Radiance (mwatts/sqcm-str-μm) Band 4	Band 5	Band 6	Band Ratio, 5/4	Suspended Solids mg/ℓ	Water Color (Forel)	Secchi Visibility (m)
	Value (Std.dev.)[a]						
39	3.89 (0.09)	1.39 (0.04)	0.36 (0.05)	0.356	1.7	3	10.0
40	3.92 (0.06)	1.39 (0.07)	0.17 (0.05)	0.353	1.1	3	11.7
41	4.27 (0.07)	1.39 (0.05)	0.23 (0.04)	0.325	1.6	3	10.0
42	3.98 (0.06)	1.43 (0.06)	0.29 (0.05)	0.359	1.8	3.5	13.3
43	4.56 (0.09)	1.39 (0.02)	0.27 (0.06)	0.303	1.8	5	7.7
44	5.45 (0.06)	1.69 (0.06)	0.27 (0.05)	0.310	2.3	4	5.3
45	6.13 (0.05)	1.84 (0.05)	0.50 (0.05)	0.300	3.2	6	5.3
46	3.96 (0.08)	1.28 (0.04)	0.21 (0.07)	0.324	1.3	3	15.2
47	3.94 (0.05)	1.31 (0.04)	0.17 (0.05)	0.333	0.8	3	16.8
48	3.99 (0.04)	1.28 (0.03)	0.23 (0.04)	0.321	1.4	3	13.7
49	4.56 (0.08)	1.37 (0.08)	0.17 (0.05)	0.299	1.2	4	10.7
50	4.63 (0.06)	1.31 (0.04)	0.34 (0.04)	0.283	1.8	4	8.3
51	6.25 (0.09)	2.01 (0.07)	0.34 (0.06)	0.322	2.4	5	6.1

[a]Standard Deviation of the mean.

TABLE 4

Water Quality Parameters, March 26, 1976

Station Number	Radiance (mwatts/sqcm-str-μm) Band 4	Band 5	Band 6	Band Ratio 5/4	Suspended Solids mg/ℓ	Water Color (Forel)	Secchi Visibility (m)
	Value (Std.dev.)[a]						
39	4.96 (0.08)	2.27 (0.04)	0.79 (0.03)	0.457	2.2	3	20.0
40	5.06 (0.05)	2.29 (0.02)	0.93 (0.03)	0.453	1.6	3	18.3
41	5.22 (0.06)	2.27 (0.02)	0.87 (0.04)	0.435	6.9	3	15.0
42	5.20 (0.06)	2.24 (0.04)	0.93 (0.04)	0.431	1.0	4	15.0
43	5.32 (0.07)	2.29 (0.03)	0.79 (0.03)	0.431	3.0	5	15.0
44	5.54 (0.04)	2.28 (0.04)	0.83 (0.06)	0.410	5.8	5	12.0
45	6.25 (0.07)	2.35 (0.04)	0.95 (0.03)	0.376	2.3	5	8.3
46	5.03 (0.07)	2.27 (0.04)	0.83 (0.04)	0.451	0.9	3	15.0
47	5.09 (0.05)	2.26 (0.03)	0.81 (0.04)	0.444	1.4	3	18.0
48	5.25 (0.05)	2.25 (0.02)	0.83 (0.04)	0.429	1.1	3	9.0
49	5.42 (0.07)	2.28 (0.03)	0.99 (0.03)	0.420	1.3	3	11.0
50	5.98 (0.06)	2.28 (0.04)	0.93 (0.04)	0.382 .381	1.3	4	9.0
51	7.13 (0.07)	2.61 (0.04)	0.85 (0.05)	0.366	1.7	5	6.0

[a]Standard Deviation of the mean.

TABLE 5

Water Quality Parameters, July 21, 1976

Station Number	Radiance (mwatts/sqcm-str-μm) Band 4 Value (Std.dev.)[a]	Band 5	Band 6	Band Ratio, 5/4	Turbidity (FTU)	Suspended Solids (mg/1)	Secchi Visibility (m)	Near-surface Attenuation Coeff. (m^{-1}) Vis.	Green	Red
32	1.20 (0.03)	0.71 (0.01)	1.07 (0.04)	0.597	3.2	2.6	20	0.15	0.085	0.44
33	1.20 (0.03)	0.65 (0.02)	0.85 (0.06)	0.544	2.6	3.1	26	0.14	0.082	0.38
34	1.18 (0.02)	0.66 (0.01)	0.96 (0.03)	0.558	2.8	3.5	27	0.15	0.100	0.43
35	1.20 (0.03)	0.64 (0.01)	0.87 (0.09)	0.538	2.55	4.4	27	0.14	0.087	0.39
36	1.18 (0.02)	0.67 (0.01)	0.90 (0.05)	0.570	2.35	4.0	30	0.15	0.091	0.35
37	1.24 (0.02)	0.72 (0.02)	0.94 (0.04)	0.581	3.1	3.4	27	0.14	0.083	0.52
38	1.16 (0.01)	0.66 (0.01)	0.92 (0.09)	0.566	2.7	3.3	31	0.16	0.130	0.38

[a]Standard deviation of the mean

[b]Near-surface attenuation coefficients were computed from the photometer readings at five fathoms and are to the base e.

TABLE 6
Submarine Photometer Measurements

Sta. No.	Depth (ft.)	Spectral Band	Sea Cell ($\mu w/cm^2$)	Deck Cell ($\mu w/cm^2$)	Solar Elev. Angle
32	0-30	Visible	1866	7664	23.3
	30-60		1023	8330	
	60-90		716	8597	
	90-120		409	8330	
	120-150		154	8330	
32	0-30	Red	24.0	1404	
	30-60		4.1	1403	
	60-90		2.3	1403	
	90-120		1.4	1403	
	120-150		0.6	1403	
32	0-30	Blue	1469	2304	
	30-60		644	2592	
	60-90		470	2784	
	90-120		269	2784	
	120-150		84	3072	
32	0-30	Green	1585	3415	
	30-60		938	3779	
	60-90		570	4145	
	90-120		294	4023	
	120-150		145	4023	
33	0-30	Visible	2354	7664	27.5
	30-60		1366	8085	
	60-90		833	8085	
	90-120		500	7880	
	120-150		195	5000	
33	0-30	Red	36.3	1210	
	30-60		5.5	1548	
	60-90		3.0	1596	
	90-120		1.8	1596	
	120-150		0.7	1548	
33	0-30	Blue	1152	2688	
	30-60		777	2784	
	60-90		547	2880	
	90-120		288	2784	
	120-150		101	2880	

TABLE 6 (continued)
Submarine Photometer Measurements

Sta. No.	Depth (ft.)	Spectral Band	Sea Cell ($\mu w/cm^2$)	Deck Cell ($\mu w/cm^2$)	Solar Elev. Angle
33	0-30	Green	2133	4600	27.5
	30-60		1196	4815	
	60-90		810	4998	
	90-120		397	4876	
	120-150		164	4754	
34	0-30	Visible	2968	11328	36.1
	30-60		1833	12660	
	60-90		1200	12995	
	90-120		860	12660	
	120-150		379	13000	
34	0-30	Red	47.2	2419	
	30-60		8.1	2322	
	60-90		4.1	2655	
	90-120		2.9	2655	
	120-150		1.2	2655	
34	0-30	Blue	1440	3840	
	30-60		922	4416	
	60-90		701	4512	
	90-120		470	4512	
	120-150		213	4608	
34	0-30	Green	2804	6892	
	30-60		1585	8096	
	60-90		957	7912	
	90-120		589	8096	
	120-150		286	8280	
35	0-30	Visible	5117	17326	48.9
	30-60		2456	16660	
	60-90		1866	17660	
	90-120		1166	18330	
	120-150		634	18000	
35	0-30	Red	92.9	3338	
	30-60		11.1	3245	
	60-90		6.9	3540	
	90-120		4.3	3390	
	120-150		2.1	3400	

TABLE 6 (continued)
Submarine Photometer Measurements

Sta. No.	Depth (ft.)	Spectral Band	Sea Cell ($\mu w/cm^2$)	Deck Cell ($\mu w/cm^2$)	Solar Elev. Angle
35	0-30	Blue	2400	6144	48.9
	30-60		1498	5472	
	60-90		1008	6144	
	90-120		710	6432	
	120-150		336	6624	
35	0-30	Green	4144	9752	
	30-60		2438	9568	
	60-90		1524	9936	
	90-120		883	10490	
	120-150		482	10304	
36	0-30	Visible	5526	21658	65.3
	30-60		3582	21990	
	60-90		2466	21658	
	90-120		1666	21658	
	120-150		1200	21660	
36	0-30	Red	17.4	4130	
	30-60		11.1	4130	
	60-90		8.7	4130	
	90-120		5.8	4130	
	120-150		3.6	4130	
36	0-30	Blue	2592	7776	
	30-60		1632	7776	
	60-90		1325	7776	
	90-120		922	7776	
	120-150		614	7776	
36	0-30	Green	5120	11776	
	30-60		3048	11581	
	60-90		1950	11776	
	90-120		1362	11960	
	120-150		773	12328	
37	0-30	Visible	4605	23657	77.1
	30-60		4503	23990	
	60-90		3275	23990	
	90-120		2265	12190	
	120-150		1532	23990	

TABLE 6 (continued)
Submarine Photometer Measurements

Sta. No.	Depth (ft.)	Spectral Band	Sea Cell ($\mu w/cm^2$)	Deck Cell ($\mu w/cm^2$)	Solar Elev. Angle
37	0-30	Red	30.5	4425	77.1
	30-60		23.6	4425	
	60-90		12.1	4425	
	90-120		8.4	4425	
	120-150		5.5	4425	
37	0-30	Blue	1757	8064	
	30-60		2448	8352	
	60-90		1728	8064	
	90-120		1344	8352	
	120-150		893	8352	
37	0-30	Green	5181	12880	
	30-60		3840	12512	
	60-90		----	12696	
	90-120		1707	12190	
	120-150		1141	12880	
38	0-30	Visible	5629	24656	81.8
	30-60		4605	24656	
	60-90		2632	24656	
	90-120		----	24990	
	120-150		1933	24323	
38	0-30	Red	132.8	4425	
	30-60		11.6	4425	
	60-90		----	4425	
	90-120		9.2	4425	
	120-150		6.3	4425	
38	0-30	Blue	2880	8352	
	30-60		2304	8352	
	60-90		1354	8352	
	90-120		----	8352	
	120-150		1066	8352	
38	0-30	Green	3535	13248	
	30-60		3048	12880	
	60-90		2438	12880	
	90-120		2072	13064	
	120-150		1398	13064	

LANDSAT DATA ACQUISITION AND PROCESSING

Landsat data have been obtained in the form of nine track, 800 bpi, computer compatible tapes (CCT) which record data in a digital format. Landsat digital data has various geometric distortions induced by factors such as orbital motion, earth rotation, and sensor operations. For this study it was essential to match the station position with the corresponding image area. This was required due to variations of turbidity within the scene.

The following is an outline describing the approach utilized to analyze three sets of computer tapes recorded by Landsat 1 on March 26, 1976 and by Landsat 2 on February 28, 1976 and July 21, 1976 in the Tampa Bay Area (Figures 4, 5, and 6). Data recorded on March 26 and February 28, 1976 were recorded in the high gain mode (bands 4 and 5). Data from the July 21, 1976 overpass were in the normal gain mode.

(1) Stations were delineated on an acetate overlay according to latitude and longitude indicated on 9.5 inch by 9.5 inch Landsat positive transparencies. Using a line-cell template, positions were translated into a line-cell position.

(2) The sampling site areas were viewed on the color display at the Remote Sensing Center. Scan line

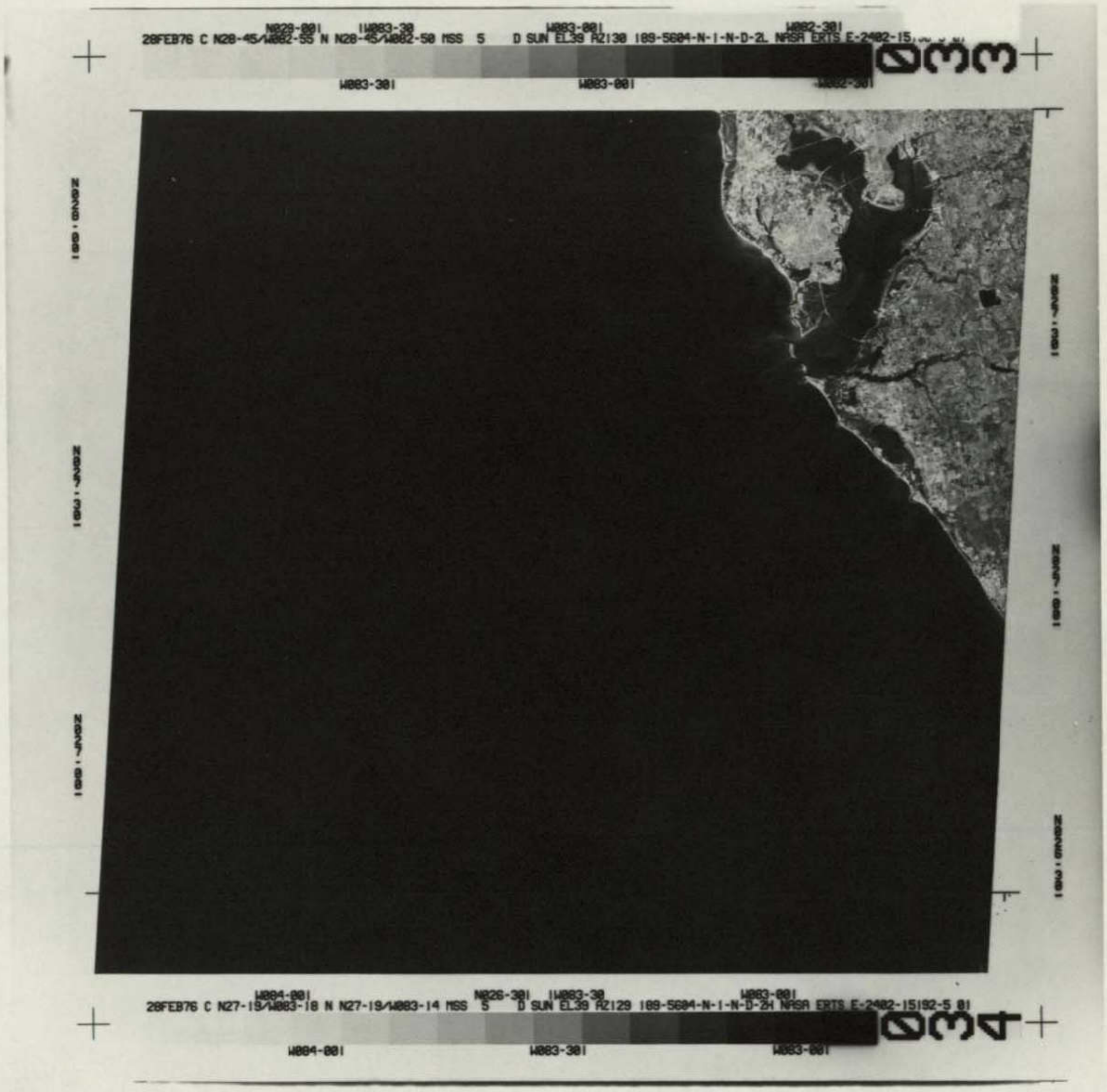


Fig. 4. Landsat Band 5 image of Tampa Bay Area, Florida, February 28, 1976.

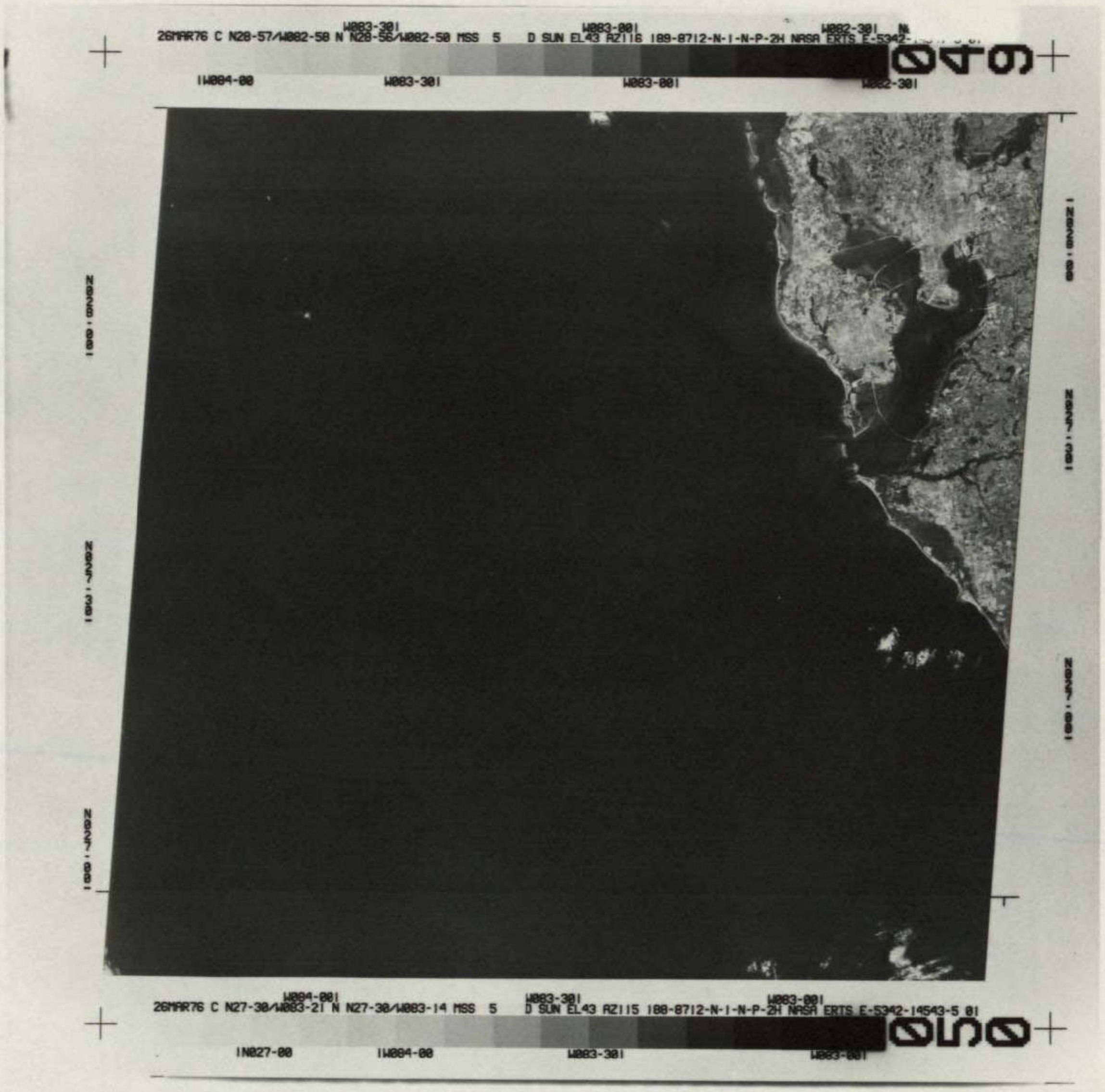


Fig. 5. Landsat Band 5 image of Tampa Bay Area, Florida, March 26, 1976.

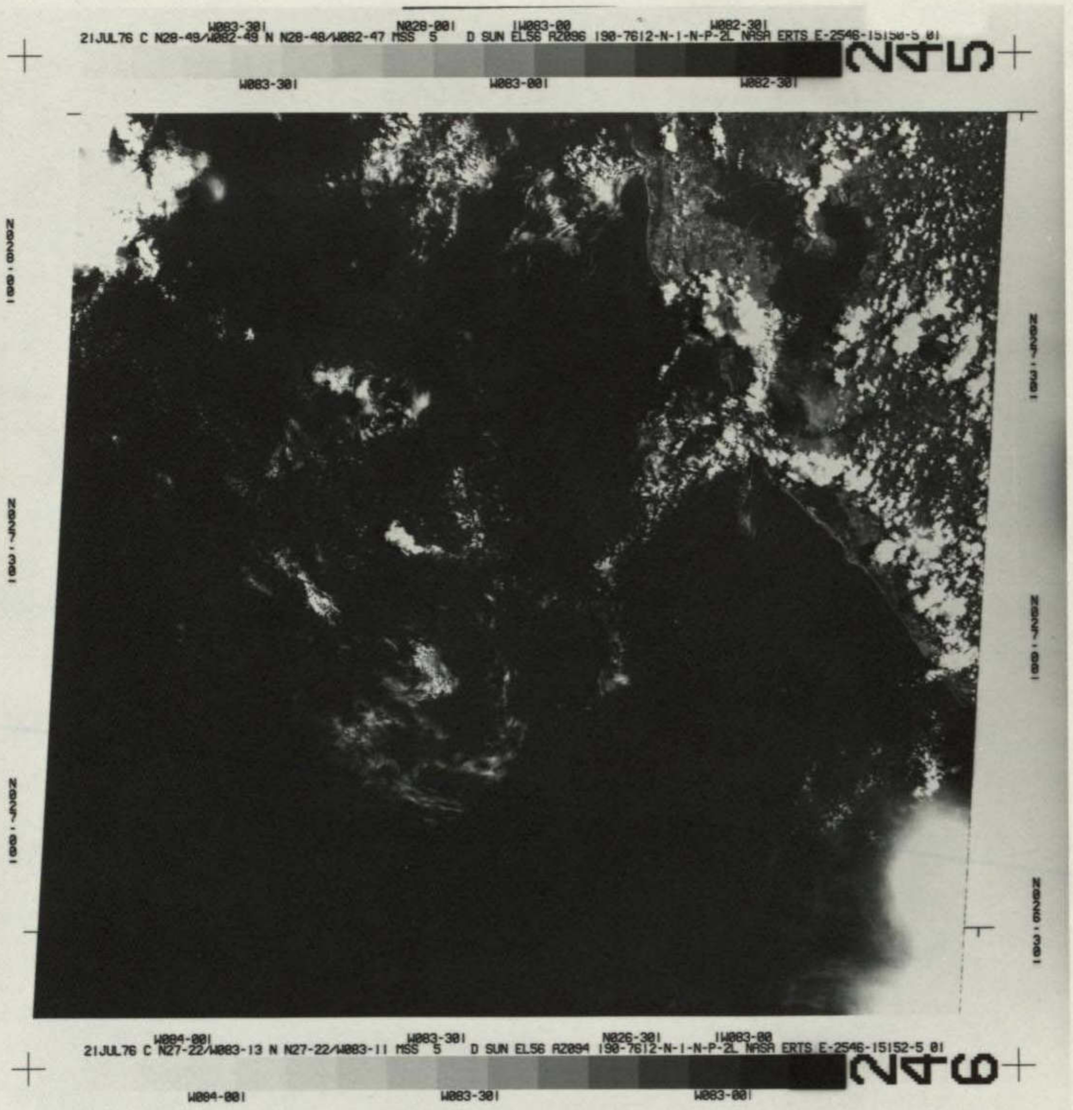


Fig. 6. Landsat Band 5 image of Tampa Bay Area, Florida, July 21, 1976.

detector noise was apparent. The noisy scan lines are also apparent on the grey scale map generated (Figure 7). The magnitude of the effect of this detector noise on quantitative radiance values is not known. By utilizing the color display to position the image area (3 by 3 pixel area) such that the sample area did not fall on the noisy scan line, the effects of the detector noise were minimized in determining quantitative radiance values.

Increasing the image area (3 by 3 pixel area) to a larger image area (8 by 8 pixel area) generally increases the standard deviation as shown in the site processing reports (Figures 8 and 9). Band 4 standard deviation increased from 0.03 mwatts/sqcm-str in the 3 by 3 pixel area to 0.07 in the 8 by 8 pixel area in Band 4, from 0.03 to 0.04 in Band 5, and from 0.09 to 0.24 in Band 6. This increase is probably due to the increased detector noise found in the larger image area.

(3) Site processing reports were generated to obtain radiance values for a specified image area. The site processing report gives radiance values converted from voltage counts for the average of all pixels in the sample area. The conversion factor used is a

function of whether the imagery is in the high gain mode or in the normal gain mode. A correction is made for solar elevation angle. A standard deviation of the individual pixel radiance values for each band is also computed. Ratios of several bands (5/4, 7/4, 7/5) are also given. Site processing reports of all stations are in Appendix III.

A grey scale map showing a 180 by 180 pixel area can be generated. The image area is located in the center of the grey scale map. Landsat 1 and 2 MSS's do not record a square pixel; instead, the pixel is approximately 57 m. wide and 79 m. long. The ratio of width to length of the pixels within the grey scale map of Figure 7 is five to seven, resulting in a fairly good geometric representation of the data. The center of the grey scale map is the location of station number 51, located about four miles from the entrance of Tampa Bay. The grey scale map shows the turbidity plumes extending from the Bay and a small island at the entrance to Tampa Bay.

Landsat quantitative radiance values for Bands 4, 5, and 6 at stations 39 to 51 are presented in Tables 3 and 4. Landsat quantitative radiance values

at stations 32 to 38 are presented in Table 5. The average radiance values increased from February to March for stations 39-51. The lower values in July were due to stations 32 to 38 being located further offshore in clearer water.

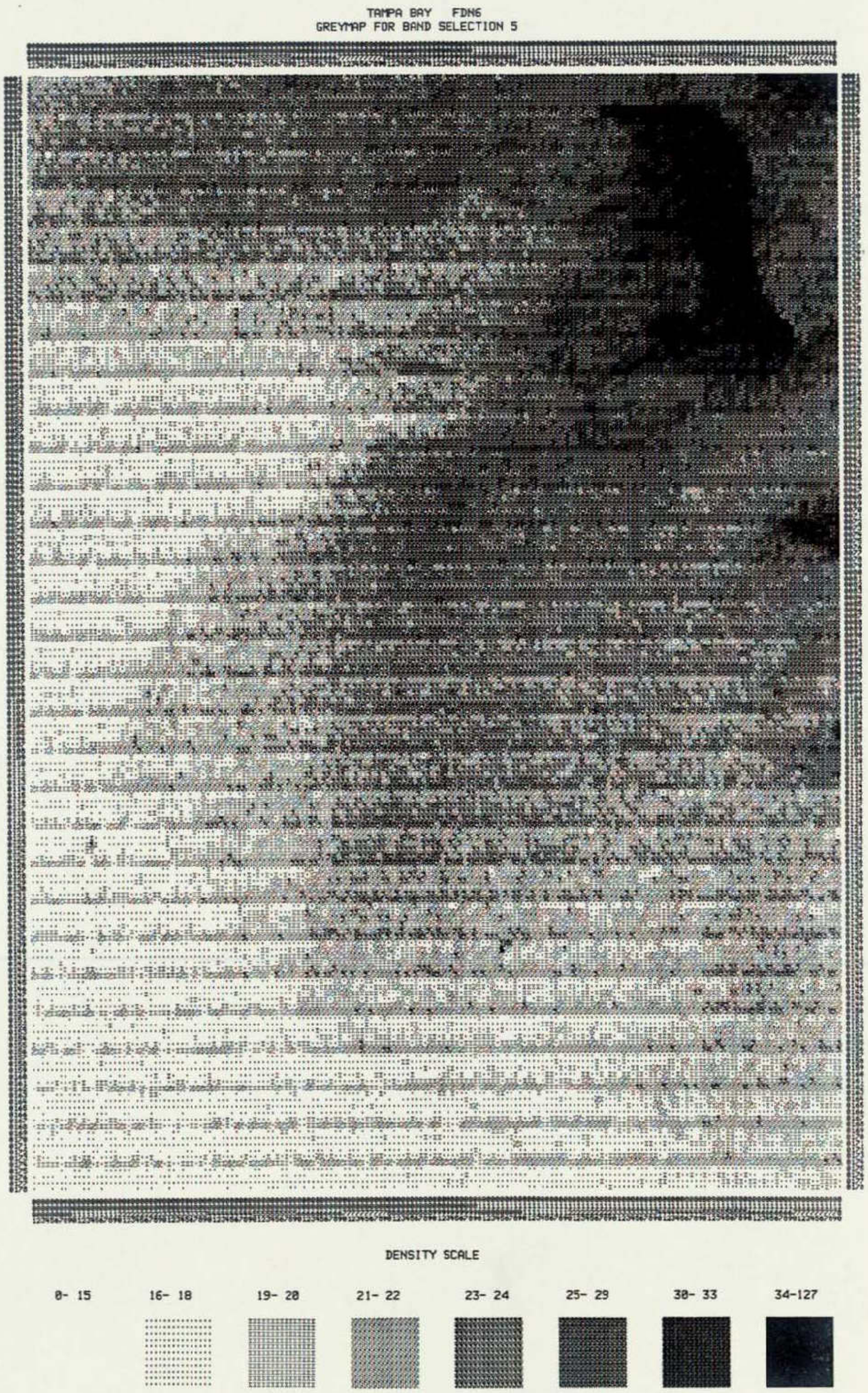


Fig. 7. Grey Scale Map, Station No. 51, entrance to Tampa Bay, Florida, February 28, 1976.

* SITE PROCESSING REPORT *

* LANDSAT-2 546-15152 *

SITE DESIGNATOR: TMP7 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 07/21/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

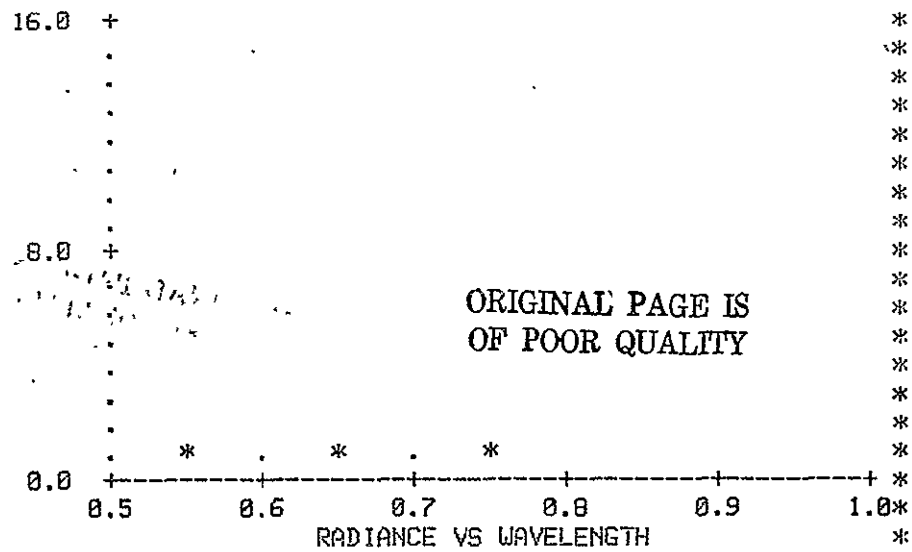
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.16	0.03	.5 - .6
BAND 5	0.66	0.03	.6 - .7
BAND 6	0.92	0.09	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.395	-0.316	0.000
BAND 5	-0.395	1.000	0.800	0.000
BAND 6	-0.316	0.800	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.816 TVI7= 0.707

5/4= 0.566 7/4= 0.000 7/5= 0.000



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PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 05/13/77

Fig. 8. Site Processing Report, 3 by 3 pixel area, Station No. 51, July 21, 1976.

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****************************************************************
*                   ****************************               *
*                   * SITE PROCESSING REPORT *                 *
*                   *  LANDSAT-2  546-15152  *                 *
*                   ****************************               *
*                                                              *
*  SITE DESIGNATOR:   TMP7 11      TOTAL AREA    73.9  ACRES   *
*  DATE AQUIRED:      07/21/76       TOTAL POINTS     64       *
*                                                              *
*    ***CORRECTED FOR SUN ELEVATION    56  DEGREES***          *
*                                                              *
*         RADIANCE(MWATTS/SQCM-STR-MICROMETER)                 *
*                                                              *
*                  MEAN     STANDARD   WAVELENGTH              *
*                           DEVIATION  (MICROMETERS)           *
*      BAND 4      1.18       0.08       .5 - .6               *
*      BAND 5      0.65       0.05       .6 - .7               *
*      BAND 6      0.93       0.14       .7 - .8               *
*      BAND 7      0.08       0.14       .8 -1.1               *
*                                                              *
*                          NORMALIZED COVARIANCES              *
*                 BAND 4    BAND 5    BAND 6    BAND 7         *
*      BAND 4      1.000    -0.172    0.129     -0.027         *
*      BAND 5     -0.172     1.000    0.201     -0.041         *
*      BAND 6      0.129     0.201    1.000     -0.203         *
*      BAND 7     -0.027    -0.041   -0.203      1.000         *
*                                                              *
*                TVI6= 0.821     TVI7= 0.528                   *
*         5/4= 0.554     7/4= 0.069     7/5= 0.124             *
*                                                              *
* 16.0  +                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*  8.0  +                                                      *
*       .                                                      *
*       ..                                                     *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .    *     .     *     .     *                         *
*  0.0  +---------+---------+---------+---------+---------+    *
*      0.5       0.6       0.7       0.8       0.9       1.0   *
*                   RADIANCE VS WAVELENGTH                     *
*                                                              *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER     *
*              DATA ANALYSIS LABORATORY  05/13/77              *
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Fig. 9. Site Processing Report, 8 by 8 pixel area, Station No. 51, July 21, 1977

DISCUSSION

Spearman rank correlation coefficients between parameters listed in Tables 3, 4, and 5 are presented in Tables 7, 8, and 9, respectively. Correlation coefficients were calculated by finding the ranks of the values of each variable and then computing the product-moment correlation coefficient of the two sets of ranks (2).

Since the composition and intensity of radiance values varies according to solar elevation and atmospheric conditions, a separate analysis was completed for each sampling date. The relationships between the water quality parameters and the satellite imagery are discussed in the following sections.

Band Ratio, 5/4

Band Ratio, 5/4, is the ratio of the radiance value in Band 5 to that in Band 4. The value of the ratio is higher in clear sea water than in turbid coastal water. This is due to the spectral distribution of upwelling light peaking at 450 nm. in clear sea water and shifting towards longer wavelengths with increased turbidity. This shift is attributed to highly wavelength-selective scattering. According to the principle of attenuation in clear sea water, decreased transmittance reduces the shortwave part of the spectrum more than the long-wave part, and shifts the maximum transmittance towards longer wavelengths because of selective absorption by particles.

Table 7

Linear Correlation Matrix, February 28, 1976

	Band 4	Band 5	Band 6	Band Ratio, 5/4	Suspended Solids	Water Color	Secchi Disk Depth
Band 4	1.00						
Band 5	0.93	1.00					
Band 6	0.64	0.61	1.00				
Band Ratio, 5/4	-0.50	-0.15	-0.23	1.00			
Suspended Solids	0.85	0.81	0.89	-0.34	1.00		
Watercolor	0.86	0.73	0.69	-0.58	0.81	1.00	
Secchi Disk Depth	-0.82	-0.73	-0.66	0.48	-0.83	-0.76	1.00

Table 8

Linear Correlation Matrix, March 26, 1976

	Band 4	Band 5	Band 6	Band Ratio, 5/4	Suspended Solids	Water Color	Secchi Disk Depth
Band 4	1.00						
Band 5	0.88	1.00					
Band 6	0.23	-0.01	1.00				
Band Ratio, 5/4	-0.94	-0.68	-0.35	1.00			
Suspended Solids	-0.04	-0.06	-0.21	-0.02	1.00		
Water Color	0.68	0.52	-0.02	-0.72	0.21	1.00	
Secchi Disk Depth	-0.82	-0.56	-0.34	0.89	0.08	-0.53	1.00

Table 9

Linear Correlation Matrix, July 21, 1976

	Band 4	Band 5	Band 6	Band Ratio, 5/4	Turbidity	Suspended Solids	Secchi Disk Depth	Attenuation Coefficient Visible	Green	Red
Band 4	1.00									
Band 5	0.59	1.00								
Band 6	0.07	0.70	1.00							
Band Ratio, 5/4	0.21	0.90	0.85	1.00						
Turbidity	0.51	0.80	0.79	0.70	1.00					
Suspended Solids	-0.08	-0.53	-0.63	-0.61	-0.70	1.00				
Secchi Disk Depth	-0.42	-0.46	-0.67	-0.42	-0.68	0.59	1.00			
Att. Coeff. Visible	-0.80	-0.03	0.36	0.35	-0.03	-0.24	0.29	1.00		
Att. Coeff. Green	-0.76	-0.28	-0.01	-0.02	-0.16	-0.02	0.58	0.86	1.00	
Att. Coeff. Red	0.77	0.77	0.47	0.49	0.84	-0.34	-0.40	-0.33	-0.30	1.00

This leads to the characteristic color change of the sea from blue to blue-green to green to brown as an observer approaches nearshore waters from deep ocean waters. Only in very turbid waters does the red aspect in the upwelling light become significant compared with the blue.

The correlation of Band Ratio, 5/4, to Band 4 would be expected to be negative, as radiance in Band 4 increases in more highly turbid waters. This correlation is established in the March data and to a lesser degree in the February data.

The correlation of Band Ratio, 5/4, to Band 5 should be positive. The February and March values do not support this. However, the July correlation is very high (0.90).

Band Ratio, 5/4, needs to be corrected for the increased path length through the atmosphere due to solar elevation angle and the change in composition and intensity of light resulting from increased path length to make a valid comparison of the three dates. At low solar elevation angles increased atmospheric path length results in a larger amount of scattering of blue-green light, increasing the Landsat Band 4 radiance due to dominant skylight irradiance.

Turbidity

Turbidity measurements were taken only during the July 21, 1976 sampling trip at Station No. 32 to 38. These stations are approximately sixty miles offshore in the Gulf of Mexico where little variation in turbidity was anticipated.

Turbidity values ranged from 2.35 FTU to 3.2 FTU. This range is so small that the correlation coefficient between turbidity and red band radiance (0.80) is probably much smaller than it would have been if there had been a full range of turbidity values.

Suspended Solids

Suspended solids data are available for the three sampling dates. Values from the February sampling trip correlate reasonably well (0.85, 0.81, 0.89) with the radiance values from Bands 4, 5, and 6, respectively. The sampling stations were oriented perpendicular to the coastline and the suspended solids ranged from 0.8 mg/l to 3.2 mg/l. Sampling Station No. 39 was located 40 miles offshore, Station No. 45 was 2 miles offshore, Station No. 46 was 40 miles offshore and Station No. 51 was 4 miles offshore.

The suspended solids data from March are of questionable accuracy since they did not correlate with either water color, Secchi disk depth, or with radiance values.

On July 21, 1976 the suspended solids samples were collected from the Texas Clipper rather than from the lifeboat. The lifeboat was on the station but the Clipper was several miles from the station. Not being on station at the time of sampling combined with the small range in values (2.6 to 4.0 mg/l), probably resulted in the poor correlation coefficients (-0.08, -0.53, and -0.63 for Bands 4, 5, and 6 respectively).

Water Color

Water color determinations were made for the February and March sampling dates (Station Nos. 39 through 51). Measurements were made by comparing the color of the sea water sample to a Forel-Ule scale. The accuracy of the Forel-Ule comparator depends on the color discrimination ability of the individual making the reading and is generally in the range of ±1 unit. Water color values listed in Tables 3 and 4 follow the general characteristic change from blue to blue-green to green to brown as an observer approaches the coast from offshore. Water color measurements taken in February correlated better with the radiance values than those taken in March (0.86, 0.73, and 0.69 vs. 0.68, 0.52, and -0.02 for Bands 4, 5, and 6, respectively). Band 4 correlated better with water color than Band 5 probably because the water color changes were primarily in the blue-green range.

Secchi Disk Visibility

Secchi disk visibility was measured during the February, March, and July sampling trips. The measurements correlated reasonably well with the radiance values for February and March but were poorly correlated in July.

For the July sampling trip, Secchi disk visibility ranged from 20 to 31 meters and increased with the time of day. The sun altitude was only 23 degrees when sampling began in July and increased to 82 degrees at the last station. At least a

part of the changes in Secchi disk visibility measurements in July is believed to be due to the changes in lighting rather than water visibility.

Table 10 lists correlations between Secchi disk visibility and radiance. Neglecting the values for July, Band 4 gave higher correlation coefficients than Band 5.

Attenuation Coefficients

Radiance values computed from photometer readings (see Interim Report) are listed in Table 6. Near-surface attenuation coefficients were computed from submarine photometer radiance readings at five fathoms.

Attenuation coefficients determined from photometer measurements in the visible band deviated little from the mean, indicating the visible band may not be able to detect small differences in water quality parameters from station to station. Landsat radiance values from Band 4 correlated reasonably well with the attenuation coefficients.

TABLE 10

Correlation Coefficients between
Secchi Disk Visibility and Radiance

Date	Band 4	Band 5	Band 6
February 28, 1976	-0.82	-0.73	-0.66
March 26, 1976	-0.82	-0.56	-0.34
July 21, 1976	-0.42	-0.46	-0.67

CONCLUSIONS AND RECOMMENDATIONS

Imagery was obtained and water quality parameters were measured for three dates in 1976. Since the satellite radiance values are a function of solar elevation and atmospheric conditions, the data from each sampling trip were analyzed separately. Band 4 satellite radiance values from the February and March dates correlated well with water color and Secchi disk depth. The sampling transects on these two dates were perpendicular to the coast and the range of water quality parameters and satellite radiance values were greater than those observed in July when the sampling track was located parallel to the coast. The range of values for the July run was small and errors in measurements were a higher percentage of the total variation compared with the other two dates.

1. <u>Satellite imagery is potentially useful for quantitative evaluation of certain optical properties of the ocean.</u>

   Correlations between the satellite radiance values and water color, Secchi disk visibility, turbidity, and attenuation coefficients were generally good. The residual is due to several factors including systematic errors in the remotely sensed data, errors, small time and space variations in the water quality measurements, and errors caused by the design of the experiment. Since it is almost impossible to design the experiment so that all

stations are sampled at the time of the overpass, some residual is introduced by comparing the water quality measurements with radiance values not taken at the same time. Sampling stations should be located to obtain a full range of water quality values and allow several water quality measurements to be made for each parameter at each station. The satellite radiance values include not only light scattered in the water column but may also include light reflected from the surface and bottom, light scattered in the atmosphere, and instrument noise.

2. Satellite imagery has the potential to optically classify ocean and coastal waters.

   Satellite radiance values were closely correlated with the optical properties of the water. Satellite imagery can be used to obtain the optical properties of large areas almost instantaneously. Water mass boundaries can be delineated and coastal processes studied at a scale not possible by conventional methods.

3. It is strongly recommended that NASA develop the methodology whereby scientists and engineers can convert satellite imagery into conventional optical water quality values without field sampling at the time of each individual overpass.

   To be able to take full advantage of Landsat's synoptic and permanent record capabilities, imagery should

be in a form that can be converted to conventional optical water quality parameters. This type of information would be valuable for large area baseline and monitoring studies, and studies involving historic changes and studies showing cause and effect relationships (such as non-point source pollution and land use relationships for 208 planning studies).

APPENDIX I. LITERATURE CITED

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APPENDIX II. DRIFT BOTTLE STUDY

This section includes the results of a drift bottle study conducted in the Gulf of Mexico and in the New York Bight area. In an attempt to gain additional information concerning ocean and coastal currents, four ounce glass bottles ballasted with sand to reduce the direct effect of winds and containing three-inch by five-inch postcards, were distributed in lots of ten at various recorded intervals along the cruise track.

The Gulf of Mexico from the Atchafalya Bay, Louisiana to Galveston, Texas is represented in Figure 10. Small circles denote points at which ten bottles were released and arrows indicate number of bottles recovered and relative drift direction.

Figure 11 describes drift bottles released in the eastern Gulf of Mexico off the west coast of Florida.. In a similar manner, ten drift bottles were released at each station (indicated by a small circle) and arrows indicate relative drift direction within the figure. Stations with letters enclosed within a circle indicate those bottles that drifted through the Straits of Florida and impinged on the eastern coast of Florida. Figure 12 shows the points of impact along the Florida coast.

Drift bottles released from the Texas Clipper on July 20-21, 1976 in the vicinity of the September 1972 Florida west coast red tide, reached the Florida east coast in 20 to 59 days (15 bottles out of 50 released). Murphy (14) conducted a similar study and reported one bottle reached the east coast

beaches in nine days, several took sixteen or seventeen days, but the majority took from one to two months before being picked up on the beach.

The detached cyclonic eddy off the southwest coast of Florida shown in Figure 13 may be a factor in the one to two month travel time required for the majority of drift bottles to reach the east coast and may also explain the lag time between the outbreak of the red tide (late September 1972) and report of fish kills and presence of *G. breve.* (middle November 1972) on the east coast of Florida.

Fifteen bottles out of forty released from a total of four stations (Position numbers 186, 190, 206, 209) (Figure 11) in the vicinity of the west coast red tide, Marquesas Keysand southwest of Sanibel Pass, impinged on the eastern coast of Florida. Ten of the fifteen bottles beached in areas on the east coast that reported lethal and/or sublethal counts of *G. breve.* in 1972.

In the New York Bight, bottles were released along the ship's cruise track, which consisted of three 15-mile transects. Figure 14 indicates relative drift direction in the Bight.

TABLE 11

DRIFT BOTTLE STUDY

Bottle Numbers	Date	Time GCT	Position No.	Release Position φ	λ	Number Returned	Pick Up Time (Days)	Remarks
1-10	06/07/76	0200	1	29° 14.7'	94° 31.2'	1	7	Off Texas Coast
11-20	06/07/76	0300	2	29° 02.5'	94° 15.5'	4	5-7	"
21-30	06/07/76	0500	3	28° 52.5'	93° 56.0'	3	9-19	"
31-40	06/07/76	1300	6	28° 03.8'	92° 21.2'	6	12-27	"
41-50	06/07/76	1500	7	27° 53.5'	91° 55.5'	0	-	"
51-60	06/07/76	1700	8	27° 43.5'	91° 32.0'	0	-	"
61-70	06/07/76	1900	9	27° 35.5'	91° 12.5'	0	-	"
71-80	06/07/76	2100	10	27° 27.0'	90° 48.0'	0	-	Off Louisiana Coast
81-90	06/07/76	2300	11	27° 15.0'	90° 17.5'	0	-	"
91-100	06/08/76	0100	12	27° 06.0'	89° 52.0'	1	59	"
101-110	06/08/76	0300	13	27° 00.0'	89° 20.0'	0	-	"
111-120	06/08/76	0500	14	26° 57.0'	88° 50.0'	0	-	"
121-130	06/08/76	0700	15	26° 38.0'	88° 34.0	0	-	"
131-140	06/08/76	0900	16	26° 28.0'	88° 06.0'	0	-	"
141-150	06/08/76	1100	17	26° 15.0'	87° 35.0'	0	-	"
151-160	06/08/76	1300	18	26° 05.0'	87° 10.0"	0	-	Off Florida Coast
161-170	06/08/76	1500	19	25° 54.5'	86° 41.5'	0	-	"
171-180	06/08/76	1700	20	25° 31.0'	85° 48.5'	8	11-20	O "

DRIFT BOTTLE STUDY (Continued)

Bottle Numbers	Date	Time GCT	Position No.	Release Position ϕ	Release Position λ	Number Returned	Pick Up Time (Days)	Remarks
181-190	06/08/76	1900	21	25° 19.5'	85° 16.8'	3	9-12	Off Florida Coast
191-200	06/08/76	2100	22	25° 09.5'	84° 56.5'	7	9-16	"
201-210	06/08/76	2300	23	24° 50.0'	84° 49.5'	1	9	"
211-220	06/08/76	0100	24	24° 43.0'	83° 40.0'	5	9-98	"
221-230	06/09/76	0300	25	24° 38.0'	83° 35.0'	1	12	"
231-240	06/09/76	0500	26	24° 29.0'	83° 07.0'	4	31-46	"
241-250	07/08/76	1200	128	40° 34.50'	73° 20.05'	0	-	New York Bight Distribution
251-260	07/07/76	1230	130	40° 33.15'	73° 22.55'	0	-	"
261-270	07/08/76	1300	132	40° 30.85'	73° 27.80'	0	-	"
271-280	07/08/76	1330	134	40° 29.25'	73° 34.05'	0	-	"
281-290	07/08/76	1400	136	40° 29.35'	73° 41.10'	8	2-8	"
291-300	07/08/76	1430	138	40° 29.20'	73° 46.65'	0	-	"
301-310	07/08/76	1400	140	40° 25.45'	73° 48.50'	5	2-7	"
311-320	07/08/76	1530	142	40° 20.00'	73° 49.05'	8	3-4	"
321-330	07/08/76	1600	144	40° 14.80'	73° 49.60'	1	32	"
331-340	07/08/76	1630	146	40° 15.60'	73° 44.55'	0	-	"
341-350	07/08/76	1700	148	40° 22.20'	73° 45.55'	3	3	"
351-360	07/08/76	1730	150	40° 26.20'	73° 46.10'	7	2-58	New York Bight Distribution

DRIFT BOTTLE STUDY (Continued)

Bottle Numbers	Date	Time GCT	Position No.	Release Position		Number Returned	Pick Up Time (Days)	Remarks
361-370	07/08/76	1800	152	40° 27.67'	73° 51.60'	10	2	New York Bight Distribution
371-380	07/08/76	1830	154	40° 31.90'	74° 00.90'	0	-	End New York Bight Distribution
381-390	07/20/76	1600	184	24° 23.5'	82° 02.5'	1	1	Begin Gulf of Mexico Distribution
391-400	07/20/76	2400	186	25° 21.0'	83° 01.5'	6	20-38	Off Florida Coast
401-410	07/21/76	0300	187	25° 31.5'	83° 01.5'	0	-	"
411-420	07/21/76	1200	190	26° 51.5'	83° 16.5'	1	88	"
420-430	07/21/76	1600	206	27° 01.1'	83° 37.0'	4	34	"
431-440	07/21/76	2000	209	27° 25.0'	84° 14.5'	4	54-59	Off Tampa, Florida
441-450	07/21/76	2400	210	27° 50.0'	85° 13.0'	0	-	Off Florida Coast
451-460	07/22/76	0400	211	28° 45.5'	85° 27.5'	2	73-98	"
461-470	07/22/76	0800	212	29° 54.5'	85° 43.2'	8	5	"
471-480	07/22/76	1200	213	29° 54.5'	85° 43.1'	3	5-6	"
481-490	07/22/76	1600	220	30° 05.25'	85° 47.5'	8	5-29	Off Panama City, Florida
491-500	07/22/76	2000	221	30° 05.25'	85° 47.5'	4	5-65	"
501-510	07/22/76	2400	222	30° 05.25'	85° 47.5'	4	28-58	"
511-520	07/23/76	1300	223	30° 05.25'	85° 47.5'	7	6-41	"

DRIFT BOTTLE STUDY (Continued)

Bottle Numbers	Date	Time GCT	Position No.	Release Position φ	λ	Number Returned	Pick Up Time (Days)	Remarks
521-530	07/23/76	1700	238	30° 09.0'	85° 53.9'	3	1-4	Off Panama City, Fla. Florida
531-540	07/23/76	2100	241	30° 08.5'	85° 55.0'	8	5-6	"
541-550	07/24/76	0330	243	29° 10.0'	87° 31.6'	1	71	"
551-560	07/24/76	1500	244	29° 06.5'	87° 49.5'	1	104	"
561-570	07/31/76	0100	251	28° 47.0'	89° 28.0	0	-	Off Mississippi River Delta
571-580	07/31/76	0200	252	28° 35.0'	89° 40.0'	0	-	Off Louisiana Coast
581-590	07/31/76	0300	253	28° 28.0'	89° 58.0	0	-	"
591-600	07/31/76	0400	254	28° 24.0'	90° 15.5'	0	-	"
601-610	07/31/76	0500	255	28° 15.5'	90° 33.0'	0	-	"
611-620	07/31/76	0600	256	28° 12.0'	90° 51.0'	0	-	"
621-630	07/31/76	0700	257	28° 12.0'	91° 05.0'	0	-	"
631-640	07/31/76	0800	258	28° 08.5'	91° 25.0'	0	-	"
641-650	07/31/76	0900	259	28° 09.0'	91° 42.5'	0	-	Off Louisiana Coast
651-660	07/31/76	1000	260	28° 10.5'	91° 51.5'	0		"
661-670	07/31/76	1100	261	28° 12.5'	92° 15.0'	1	211	"
671-680	07/31/76	1200	262	28° 13.5'	92° 31.0'	1	262	"
681-690	07/31/76	1300	263	28° 17.0'	92° 47.5'	1	55	"

DRIFT BOTTLE STUDY (Continued)

Bottle Numbers	Date	Time GCT	Position No.	Release Position ϕ	Release Position λ	Number Returned	Pick Up Time (Days)	Remarks
691-700	07/31/76	1400	264	28° 20.0'	93° 06.0'	0	-	Off Louisiana Coast
701-710	07/31/76	1500	265	28° 24.0'	93° 23.0'	1	146	"
711-720	07/31/76	1600	266	28° 27.0'	93° 39.5'	0	-	Off Texas Coast
721-730	07/31/76	1700	267	28° 31.0'	93° 55.0'	1	64	"
731-740	07/31/76	1800	268	28° 37.0'	94° 12.5'	1	82	"
741-750	07/31/76	1900	269	28° 44.0'	94° 32.5'	6	20-26	"
751-760	07/31/76	2000	270	28° 50.0'	94° 50.5'	5	33-37	"
761-770	07/31/76	2100	271	28° 46.5'	95° 02.0'	4	19-25	"
771-780	07/31/76	2200	272	28° 49.5'	95° 11.5'	4	6-19	"

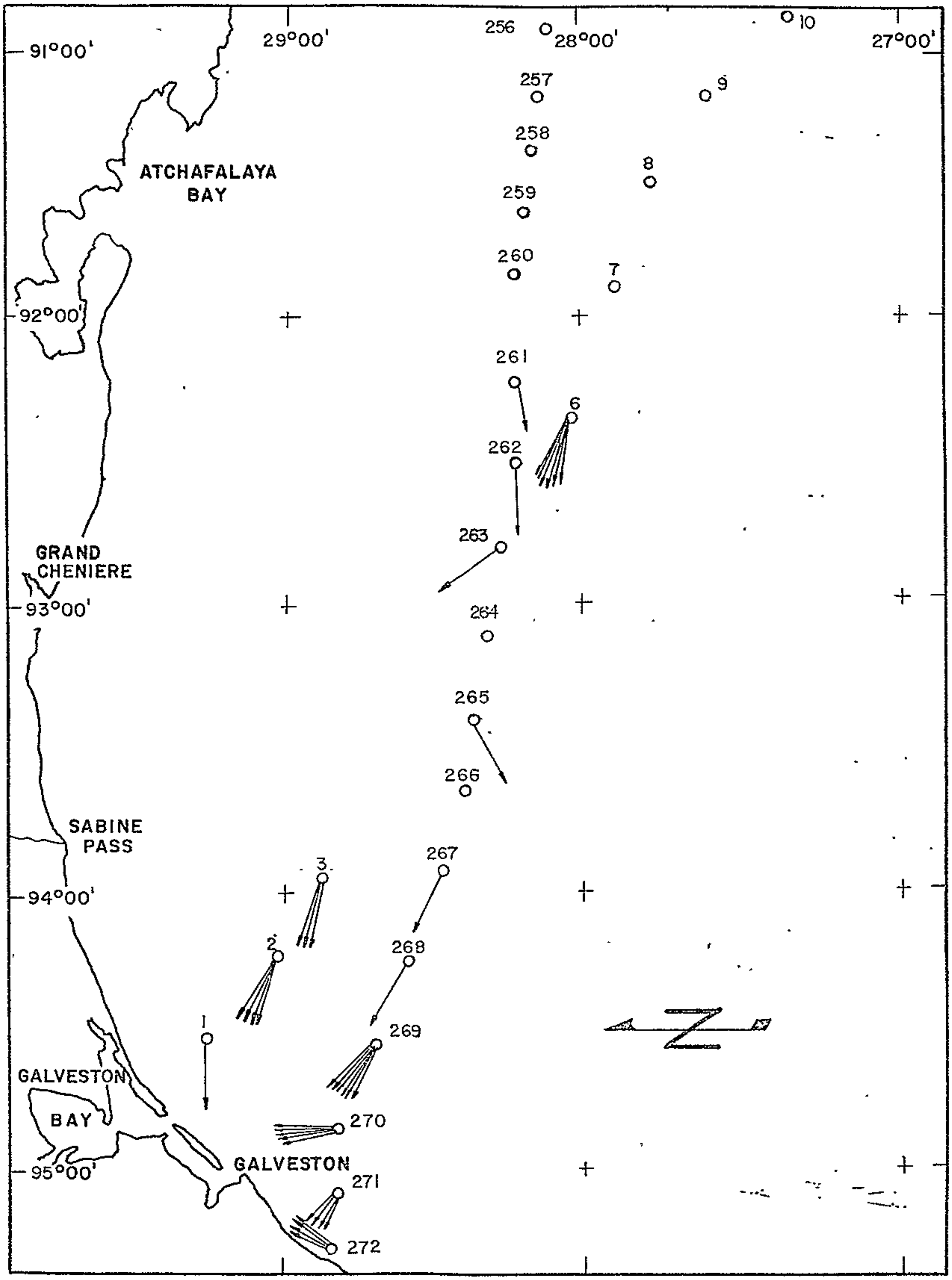


Fig.10. Gulf of Mexico drift bottle release positions, Texas and Louisiana.

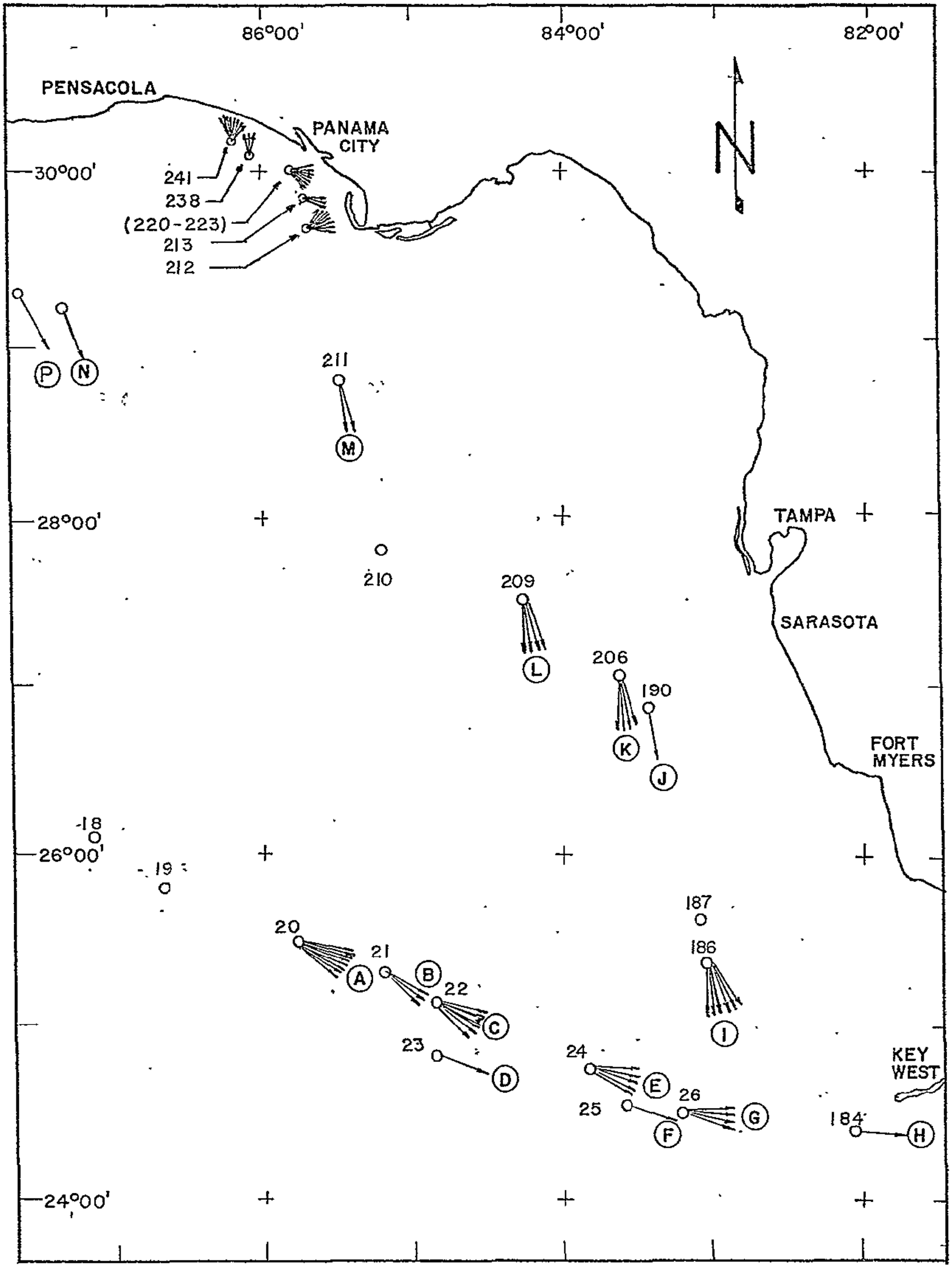


Fig.11. Drift bottle release positions, eastern Gulf of Mexico.

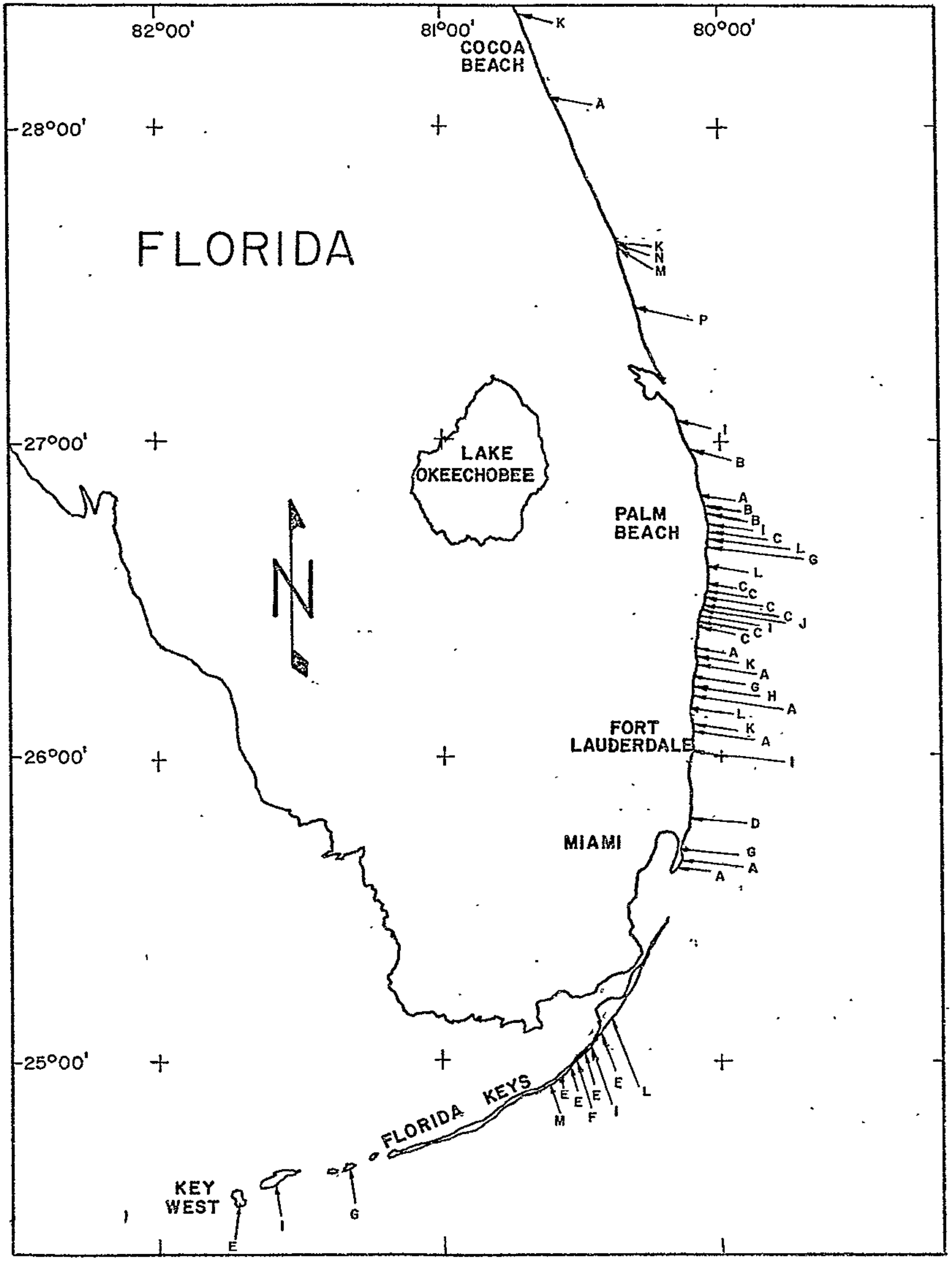


Fig.12. Location of drift bottle beaching on east coast of Florida.

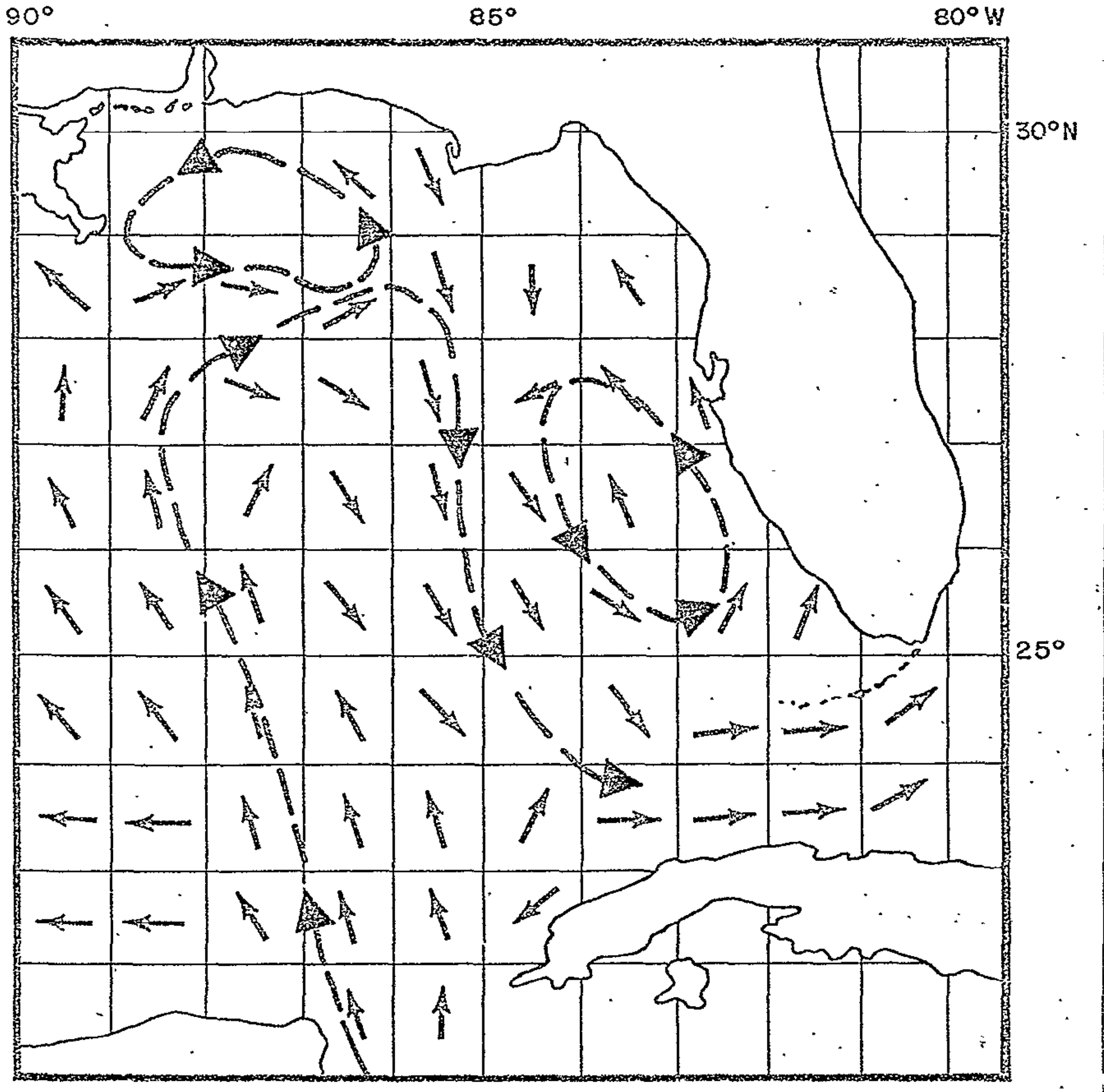


Fig. 13. Typical Loop Current in September with detached cyclonic eddies (12).

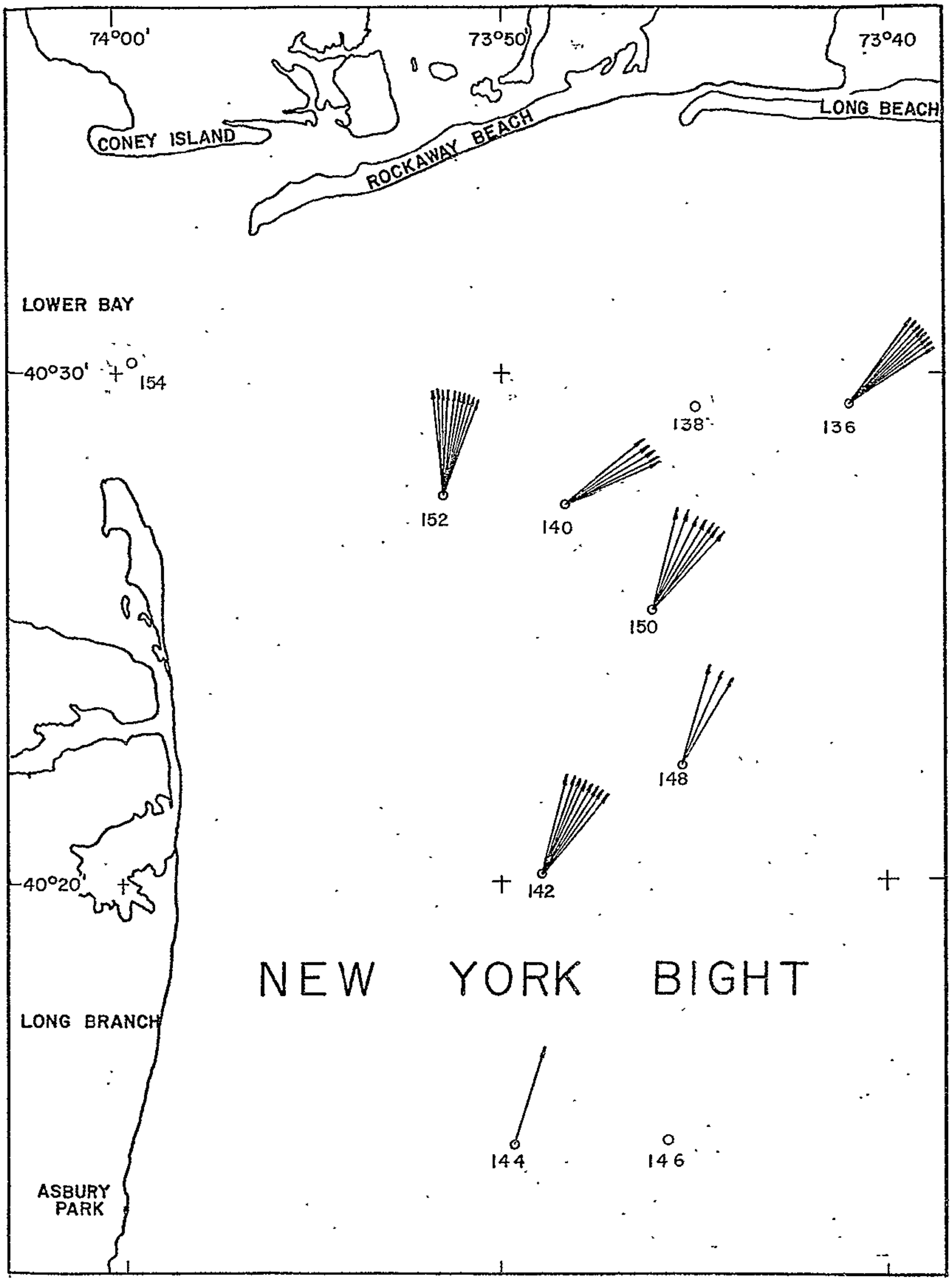


Fig.14. Drift bottle release positions, New York Bight, July 8, 1976.

APPENDIX III. SITE PROCESSING REPORTS

SITE PROCESSING REPORT

LANDSAT-2 402-15192

SITE DESIGNATOR: MOT1 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

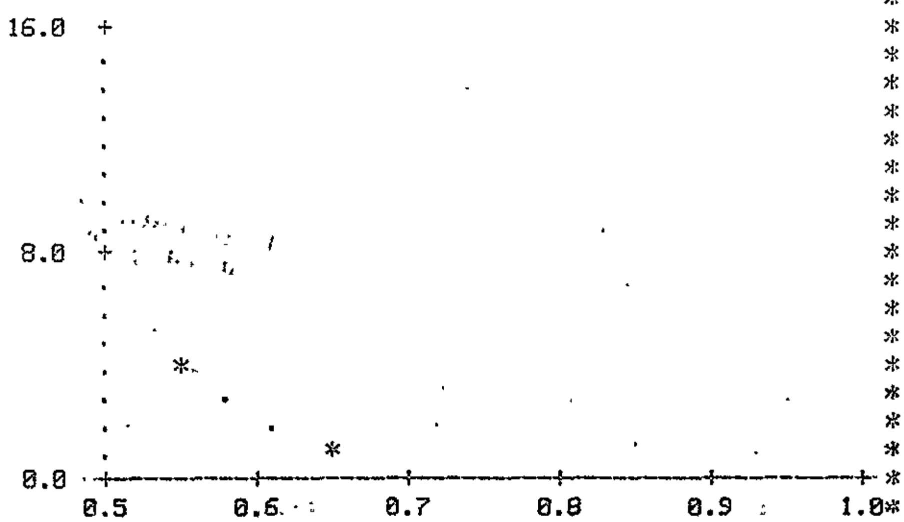
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	3.89	0.26	.5 - .6
BAND 5	1.39	0.11	.6 - .7
BAND 6	0.36	0.15	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.062	0.616	0.000
BAND 5	-0.062	1.000	0.564	0.000
BAND 6	0.616	0.564	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.301 TVI7= 0.707

5/4= 0.356 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig.15a. Site Processing Report, Sta. 39, February 28, 1976.

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***********************************************************************
*                    *****************************                    *
*                    * SITE PROCESSING REPORT *                       *
*                    *  LANDSAT-2  402-15192  *                       *
*                    *****************************                    *
*                                                                     *
*  SITE DESIGNATOR:   MOT2  7      TOTAL AREA     10.4   ACRES        *
*  DATE AQUIRED:      02/28/76       TOTAL POINTS      9              *
*                                                                     *
*    **CORRECTED FOR SUN ELEVATION     39  DEGREES***                 *
*                                                                     *
*          RADIANCE(MWATTS/SQCM-STR-MICROMETER)                       *
*                                                                     *
*                    MEAN     STANDARD   WAVELENGTH                   *
*                             DEVIATION  (MICROMETERS)                *
*        BAND 4      3.92      0.18       .5 - .6                     *
*        BAND 5      1.39      0.21       .6 - .7                     *
*        BAND 6      0.17      0.15       .7 - .8                     *
*        BAND 7      0.00      0.00       .8 -1.1                     *
*                                                                     *
*                  NORMALIZED COVARIANCES                             *
*                   BAND 4    BAND 5    BAND 6    BAND 7              *
*        BAND 4     1.000     0.676     0.554     0.000               *
*        BAND 5     0.676     1.000     0.544     0.000               *
*        BAND 6     0.554     0.544     1.000     0.000               *
*        BAND 7     0.000     0.000     0.000     0.000               *
*                                                                     *
*                  TVI6= 0.533     TVI7= 0.707                        *
*          5/4= 0.353     7/4= 0.000     7/5= 0.000                   *
*                                                                     *
* 16.0  +                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*  8.0  +                                                             *
*       .                                                             *
*       .                                                             *
*       .                                                             *
*       .    *                                                        *
*       .      .                                                      *
*       .         .                                                   *
*       .            *                                                *
*  0.0  +---------+---------+---------+---------+---------+           *
*      0.5       0.6       0.7       0.8       0.9       1.0          *
*                 RADIANCE VS WAVELENGTH                              *
*                                                                     *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER            *
*               DATA ANALYSIS LABORATORY  07/10/77                    *
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Fig.15b. Site Processing Report, Sta. 40, February 28, 1976.

* SITE PROCESSING REPORT *
* LANDSAT-2 402-15192 *

SITE DESIGNATOR: MOT3 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION . 39 DEGREES*

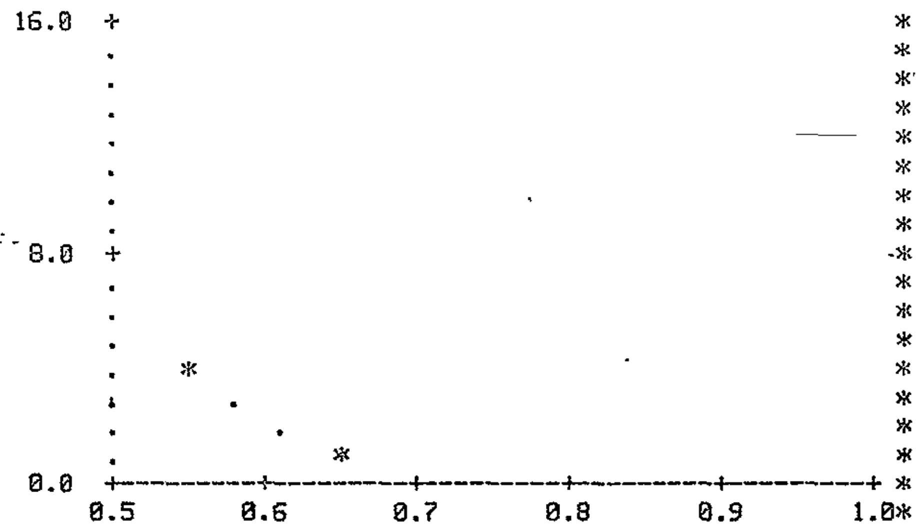
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	4.27	0.22	.5 - .6
BAND 5	1.39	0.15	.6 - .7
BAND 6	0.23	0.13	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.076	0.098	0.000
BAND 5	0.076	1.000	0.589	0.000
BAND 6	0.098	0.589	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.463 TVI7= 0.707
5/4= 0.325 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/10/77

Fig. 15c. Site Processing Report, Sta. 41, February 28, 1976.

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*************************************************************
*                    **************************              *
*                    * SITE PROCESSING REPORT *              *
*                    *  LANDSAT-2  402-15192  *              *
*                    **************************              *
*                                                            *
*  SITE DESIGNATOR:  MOT4  7     TOTAL AREA    10.4  ACRES   *
*  DATE AQUIRED:     02/28/76       TOTAL POINTS      9      *
*                                                            *
*    **CORRECTED FOR SUN ELEVATION    39  DEGREES***         *
*                                                            *
*          RADIANCE(MWATTS/SQCM-STR-MICROMETER)              *
*                                                            *
*                     MEAN    STANDARD  WAVELENGTH           *
*                             DEVIATION  (MICROMETERS)       *
*        BAND 4       3.98      0.19      .5 - .6            *
*        BAND 5       1.43      0.17      .6 - .7            *
*        BAND 6       0.29      0.14      .7 - .8            *
*        BAND 7       0.00      0.00      .8 -1.1            *
*                                                            *
*                   NORMALIZED COVARIANCES                   *
*                    BAND 4     BAND 5     BAND 6     BAND 7 *
*        BAND 4      1.000      0.582      0.732      0.000  *
*        BAND 5      0.582      1.000      0.424      0.000  *
*        BAND 6      0.732      0.424      1.000      0.000  *
*        BAND 7      0.000      0.000      0.000      0.000  *
*                                                            *
*                   TVI6= 0.400     TVI7= 0.707              *
*            5/4= 0.359     7/4= 0.000     7/5= 0.000        *
*                                                            *
* 16.0  +                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*  8.0  +                                                    *
*       .                                                    *
*       .                                                    *
*       .                                                    *
*       .    *                                               *
*       .                                                    *
*       .                                                    *
*       .              *                                     *
*  0.0  +---------+---------+---------+---------+---------+  *
*      0.5       0.6       0.7       0.8       0.9       1.0*
*                     RADIANCE VS WAVELENGTH                 *
*                                                            *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER   *
*             DATA ANALYSIS LABORATORY  07/10/77             *
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Fig. 15d. Site Processing Report, Sta. 42, February 28, 1976.

SITE PROCESSING REPORT

LANDSAT-2 402-15192

SITE DESIGNATOR: MOT5 7 — TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/28/76 — TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

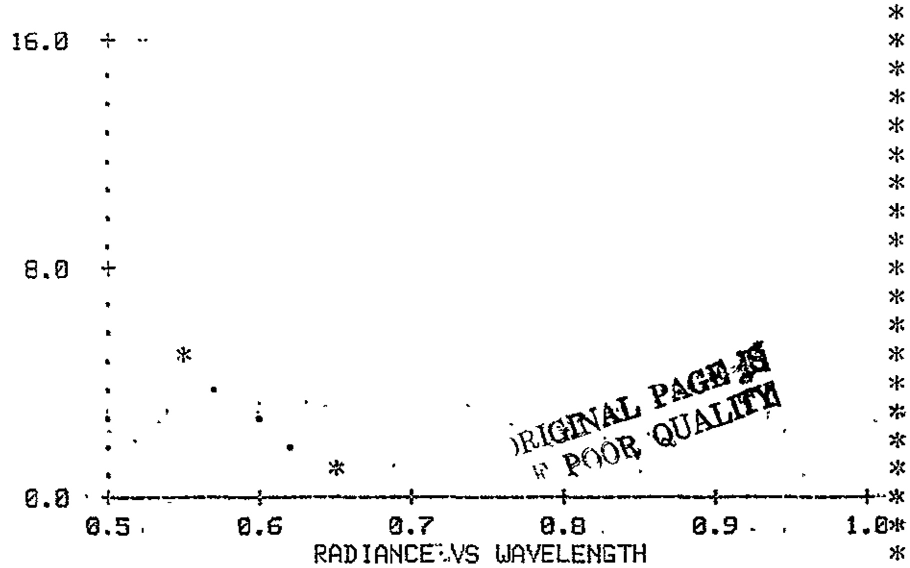
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	4.56	0.26	.5 - .6
BAND 5	1.39	0.07	.6 - .7
BAND 6	0.27	0.17	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.058	0.435	0.000
BAND 5	-0.058	1.000	-0.600	0.000
BAND 6	0.435	-0.600	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.414 TVI7= 0.707

5/4= 0.303 7/4= 0.000 7/5= 0.000



PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/07/77

Fig. 15e. Site Processing Report, Sta. 43, February 28, 1976.

SITE PROCESSING REPORT

LANDSAT-2 401-15192

SITE DESIGNATOR: MOT6 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

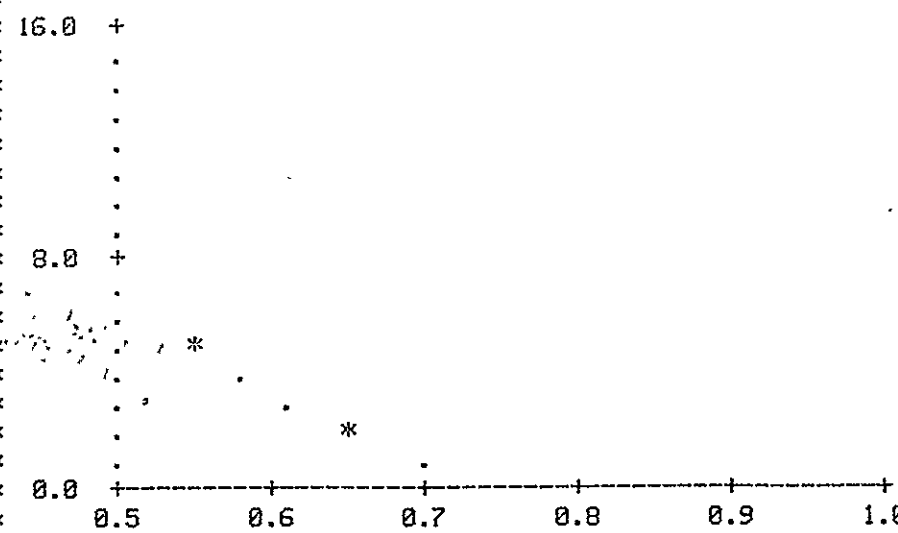
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.45	0.17	.5 - .6
BAND 5	1.69	0.18	.6 - .7
BAND 6	0.27	0.14	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.367	0.473	0.000
BAND 5	0.367	1.000	0.526	0.000
BAND 6	0.473	0.526	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.471 TVI7= 0.707

5/4= 0.310 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 07/12/77

Fig.15f. Site Processing Report, Sta. 44, February 28, 1976.

SITE PROCESSING REPORT
LANDSAT-2 402-15192

SITE DESIGNATOR: MOTE 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	6.13	0.16	.5 - .6
BAND 5	1.84	0.15	.6 - .7
BAND 6	0.50	0.16	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.209	-0.128	0.000
BAND 5	0.209	1.000	-0.464	0.000
BAND 6	-0.128	-0.464	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.265 TVI7= 0.707
5/4= 0.300 7/4= 0.000 7/5= 0.000

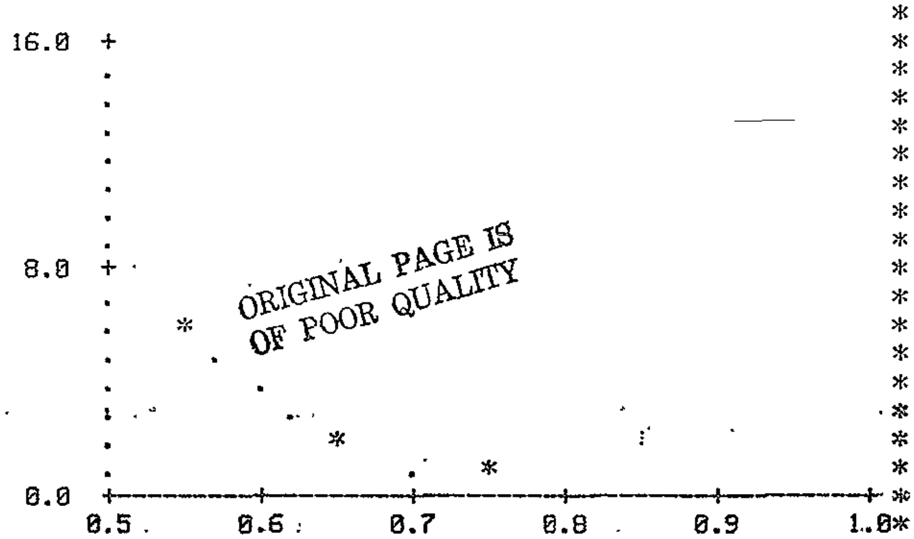


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Fig. 15g. Site Processing Report, Sta. 45, February 28, 1976.

SITE PROCESSING REPORT
LANDSAT-2 402-15192

SITE DESIGNATOR: FDN1 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

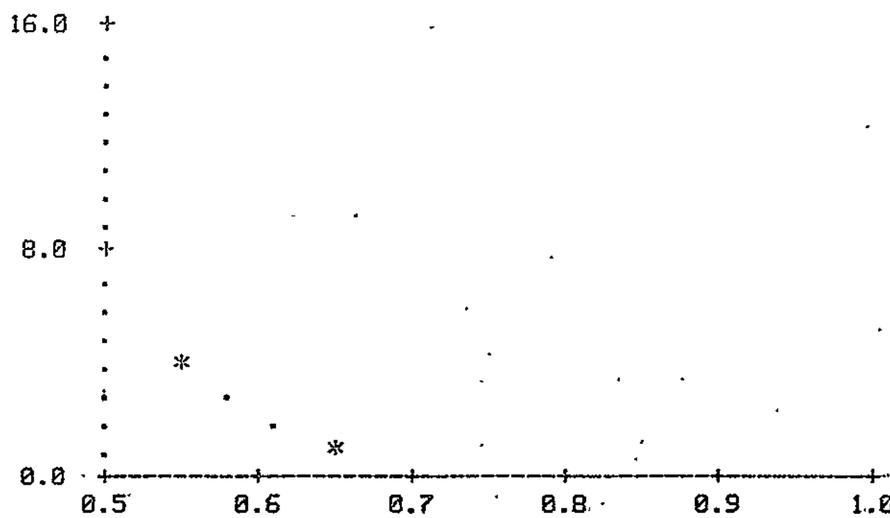
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	3.96	0.23	.5 - .6
BAND 5	1.28	0.13	.6 - .7
BAND 6	0.21	0.20	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.188	-0.024	0.000
BAND 5	0.188	1.000	0.638	0.000
BAND 6	-0.024	0.638	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.468 TVI7= 0.707
5/4= 0.324 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig. 15h. Site Processing Report, Sta. 46, February 28, 1976.

* SITE PROCESSING REPORT *
* LANDSAT-2 402-15192 *

SITE DESIGNATOR: FDN2 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

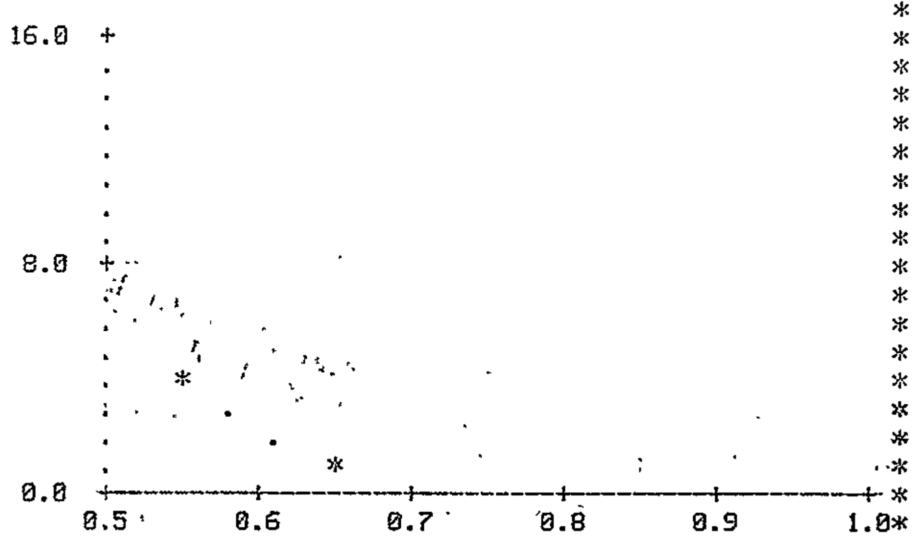
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	3.94	0.16	.5 - .6
BAND 5	1.31	0.12	.6 - .7
BAND 6	0.17	0.15	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.484	0.432	0.000
BAND 5	0.484	1.000	0.433	0.000
BAND 6	0.432	0.433	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.523 TVI7= 0.707
5/4= 0.333 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

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Fig.15i. Site Processing Report, Sta. 47, February 28, 1976.

* SITE PROCESSING REPORT *

* LANDSAT-2 402-15192 *

SITE DESIGNATOR: FDN3 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/29/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

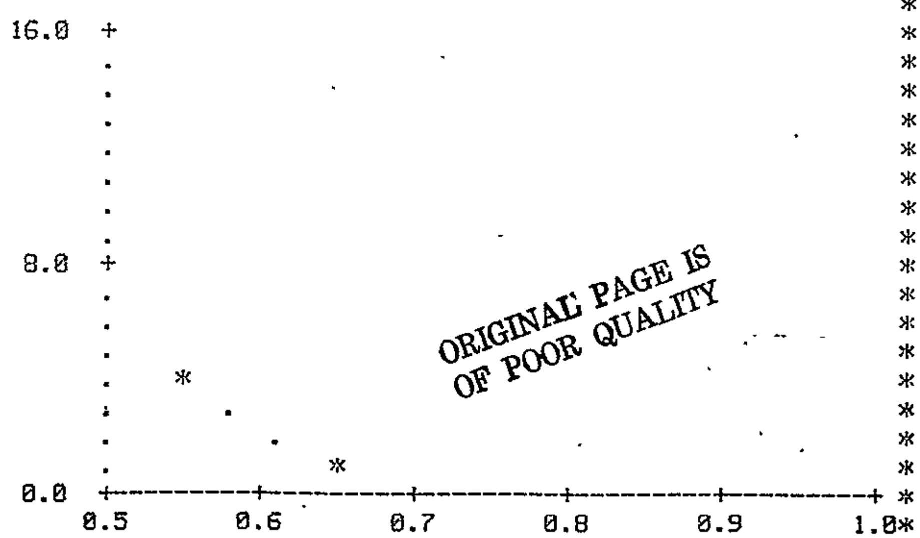
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	3.99	0.11	.5 - .6
BAND 5	1.28	0.10	.6 - .7
BAND 6	0.23	0.13	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.452	0.419	0.000
BAND 5	0.452	1.000	0.775	0.000
BAND 6	0.419	0.775	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.442 TVI7= 0.707

5/4= 0.321 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 07/10/77

Fig.15j. Site Processing Report, Sta. 48, February 28, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 402-15192 ***

SITE DESIGNATOR: FDN5 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

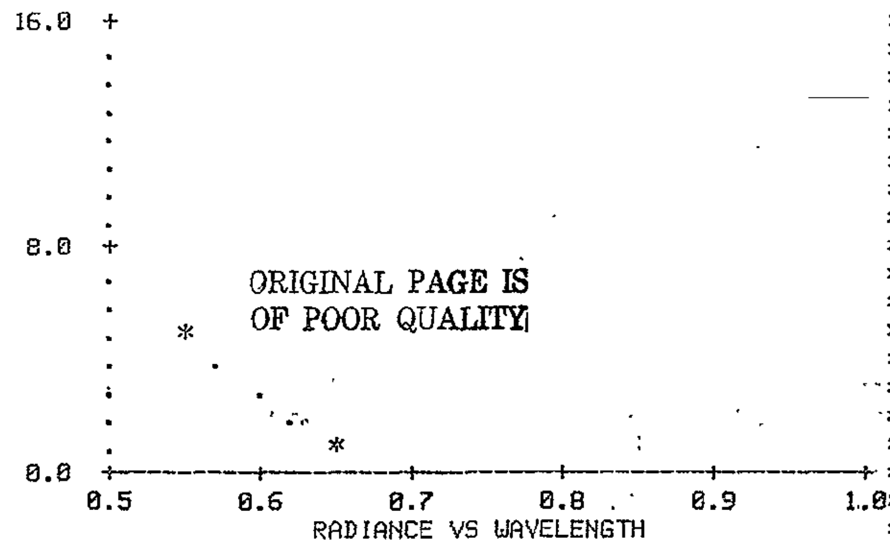
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	4.63	0.18	.5 - .6
BAND 5	1.31	0.12	.6 - .7
BAND 6	0.34	0.13	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.682	0.541	0.000
BAND 5	-0.682	1.000	-0.183	0.000
BAND 6	0.541	-0.183	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.304 TVI7= 0.707
5/4= 0.283 7/4= 0.000 7/5= 0.000



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DATA ANALYSIS LABORATORY 07/11/77

Fig.15k. Site Processing Report, Sta. 50, February 28, 1976.

*** SITE PROCESSING REPORT ***

*** LANDSAT-2 402-15192 ***

SITE DESIGNATOR: FDN4 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

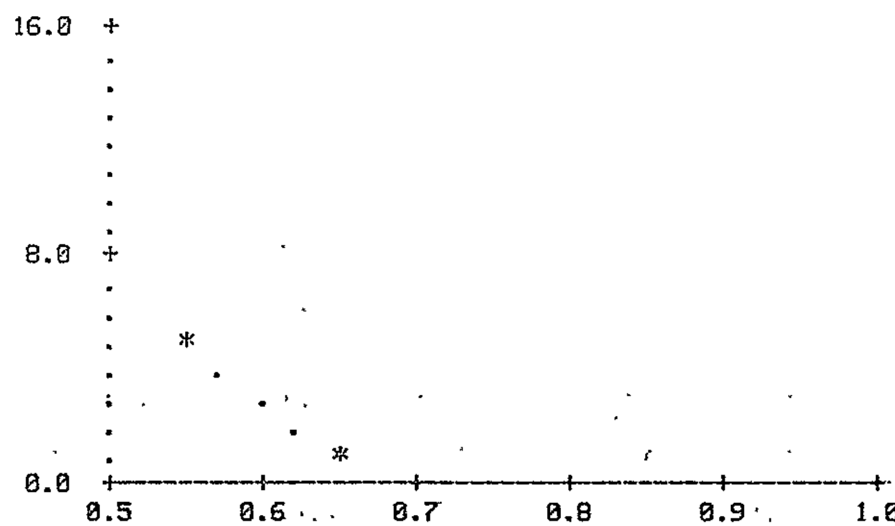
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	4.56	0.24	.5 - .6
BAND 5	1.37	0.23	.6 - .7
BAND 6	0.17	0.15	.7 - .8
BAND 7	0.02	0.05	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.178	0.500	0.426
BAND 5	-0.178	1.000	0.484	-0.194
BAND 6	0.500	0.484	1.000	0.053
BAND 7	0.426	-0.194	0.053	1.000

TVI6= 0.530 TVI7= 0.689

5/4= 0.299 7/4= 0.004 7/5= 0.013



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig.151. Site Processing Report, Sta. 49, February 28, 1976.

*** SITE PROCESSING REPORT ***

*** LANDSAT-2 402-15192 ***

SITE DESIGNATOR: FDN6 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 02/28/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 39 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

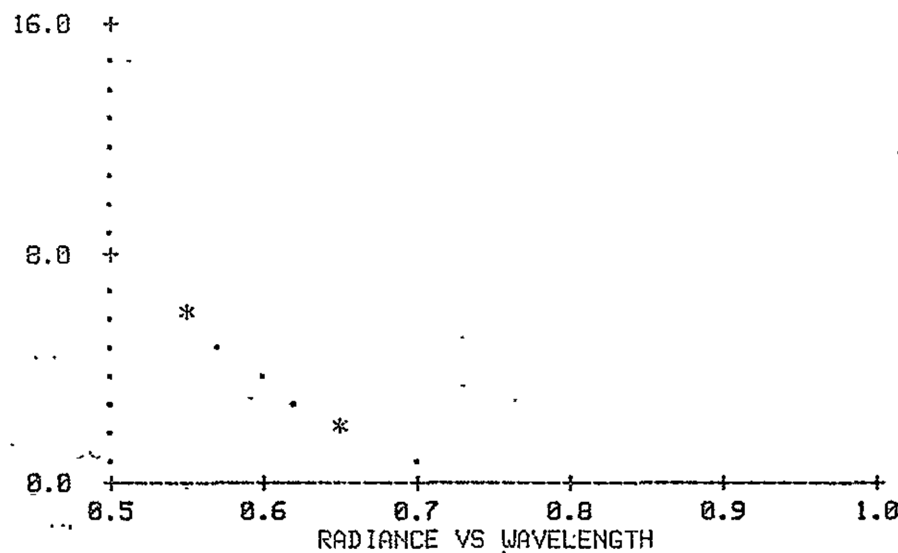
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	6.25	0.27	.5 - .6
BAND 5	2.01	0.21	.6 - .7
BAND 6	0.34	0.18	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.211	-0.032	0.000
BAND 5	-0.211	1.000	0.631	0.000
BAND 6	-0.032	0.631	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.463 TVI7= 0.707

5/4= 0.322 7/4= 0.000 7/5= 0.000



PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 07/11/77

Fig. 15m. Site Processing Report, Sta. 51, February 28, 1976.

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*                  ****************************                *
*                  * SITE PROCESSING REPORT *                  *
*                  *  LANDSAT-2  342-14543  *                  *
*                  ****************************                *
*                                                              *
*  SITE DESIGNATOR:  MOT1  7      TOTAL AREA    10.4  ACRES    *
*  DATE AQUIRED:     03/26/75        TOTAL POINTS      9       *
*                                                              *
*    **CORRECTED FOR SUN ELEVATION    43  DEGREES***           *
*                                                              *
*           RADIANCE(MWATTS/SQCM-STR-MICROMETER)               *
*                                                              *
*                    MEAN    STANDARD   WAVELENGTH             *
*                            DEVIATION  (MICROMETERS)          *
*         BAND 4     4.96     0.25       .5 - .6               *
*         BAND 5     2.27     0.12       .6 - .7               *
*         BAND 6     0.79     0.09       .7 - .8               *
*         BAND 7     0.12     0.07       .8 -1.1               *
*                                                              *
*                  NORMALIZED COVARIANCES                      *
*                   BAND 4    BAND 5    BAND 6    BAND 7       *
*         BAND 4     1.000    -0.246    -0.194     0.596       *
*         BAND 5    -0.246     1.000     0.182    -0.158       *
*         BAND 6    -0.194     0.182     1.000    -0.478       *
*         BAND 7     0.596    -0.158    -0.478     1.000       *
*                                                              *
*                  TVI6= 0.136     TVI7= 0.634                 *
*           5/4= 0.457     7/4= 0.023     7/5= 0.051           *
*                                                              *
* 16.0  +                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
*       .                                                      *
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*  8.0  +                                                      *
*       .                                                      *
*       .                                                      *
*       .    *                                                 *
*       .       .                                              *
*       .          .                                           *
*       .              *                                       *
*       .                   .    *                             *
*  0.0  +---------+---------+---------+---------+---------+    *
*      0.5       0.6       0.7       0.8       0.9       1.0   *
*                      RADIANCE VS WAVELENGTH                  *
*                                                              *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER     *
*             DATA ANALYSIS LABORATORY  07/11/77               *
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Fig. 15n. Site Processing Report, Sta. 39, March 26, 1976.

SITE PROCESSING REPORT

LANDSAT-2 342-14543

SITE DESIGNATOR: MOT2 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES

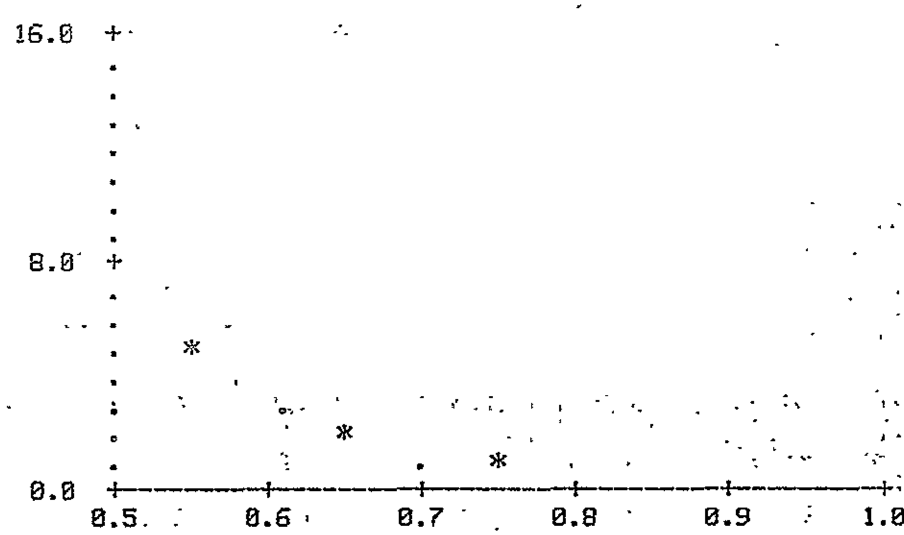
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.06	0.15	.5 - .6
BAND 5	2.29	0.05	.6 - .7
BAND 6	0.93	0.09	.7 - .8
BAND 7	0.10	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.237	0.213	-0.213
BAND 5	-0.237	1.000	-0.277	-0.139
BAND 6	0.213	-0.277	1.000	0.000
BAND 7	-0.213	-0.139	0.000	1.000

TVI6= 0.277 TVI7= 0.646
5/4= 0.453 7/4= 0.020 7/5= 0.043



RADIANCE.VS WAVELENGTH

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DATA ANALYSIS LABORATORY 07/11/77

Fig. 15o. Site Processing Report, Sta. 40, March 26, 1976.

* SITE PROCESSING REPORT *

* LANDSAT-2 342-14543 *

SITE DESIGNATOR: MOT3 7 — TOTAL AREA 10.4 ACRES

DATE AQUIRED: 03/26/76 — TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

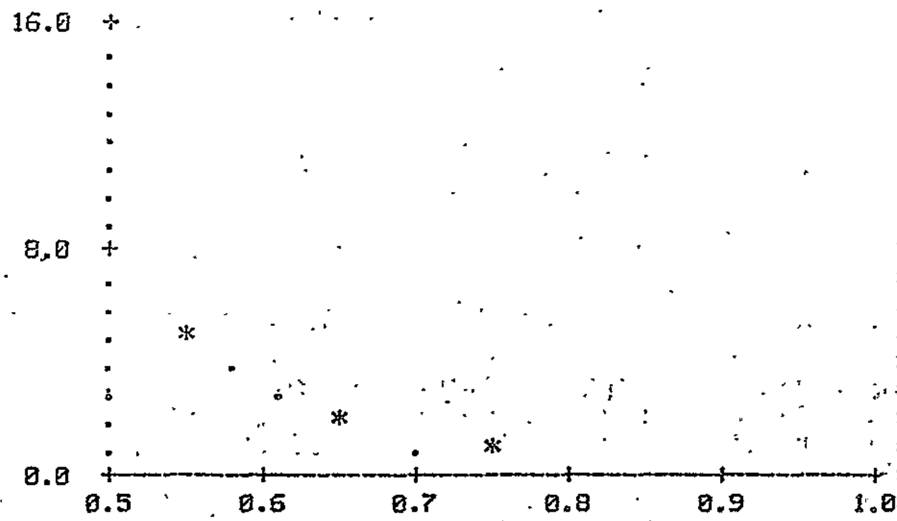
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.22	0.17	.5 - .6
BAND 5	2.27	0.06	.6 - .7
BAND 6	0.87	0.12	.7 - .8
BAND 7	0.05	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.240	0.000	-0.227
BAND 5	0.240	1.000	-0.487	0.115
BAND 6	0.000	-0.487	1.000	-0.707
BAND 7	-0.227	0.115	-0.707	1.000

TVI6= 0.235 TVI7= 0.676

5/4= 0.435 7/4= 0.010 7/5= 0.022



RADIANCE VS WAVELENGTH

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Fig. 15p. Site Processing Report, Sta. 41, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-145543 ***

SITE DESIGNATOR: MOT4 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

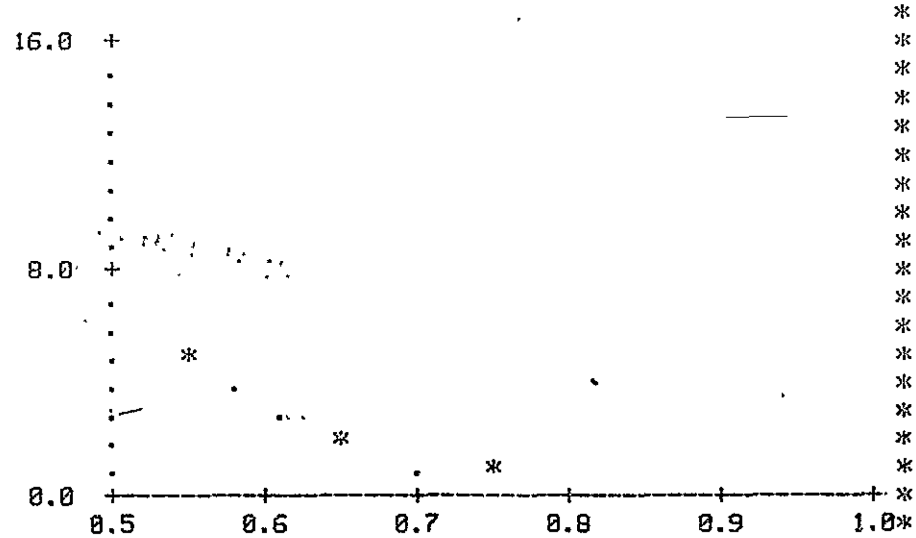
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.20	0.18	.5 - .6
BAND 5	2.24	0.13	.6 - .7
BAND 6	0.93	0.12	.7 - .8
BAND 7	0.12	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.735	0.429	-0.508
BAND 5	-0.735	1.000	-0.072	0.249
BAND 6	0.429	-0.072	1.000	-0.535
BAND 7	-0.508	0.249	-0.535	1.000

TVI6= 0.293 TVI7= 0.634
5/4= 0.431 7/4= 0.022 7/5= 0.052



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig. 15q. Site Processing Report, Sta. 42, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: MOTS 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

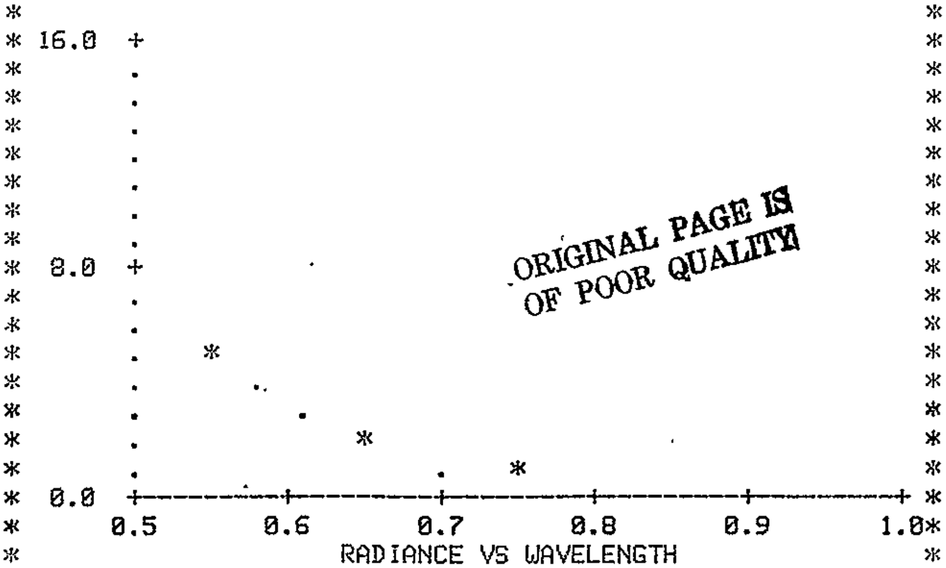
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.32	0.21	.5 - .6
BAND 5	2.29	0.10	.6 - .7
BAND 6	0.79	0.09	.7 - .8
BAND 7	0.10	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.090	0.000	0.000
BAND 5	0.090	1.000	0.291	0.131
BAND 6	0.000	0.291	1.000	0.316
BAND 7	0.000	0.131	0.316	1.000

TVI6= 0.119 TVI7= 0.646
5/4= 0.431 7/4= 0.019 7/5= 0.043



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DATA ANALYSIS LABORATORY 07/11/77

Fig. 15r. Site Processing Report, Sta. 43, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: MDT6 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES

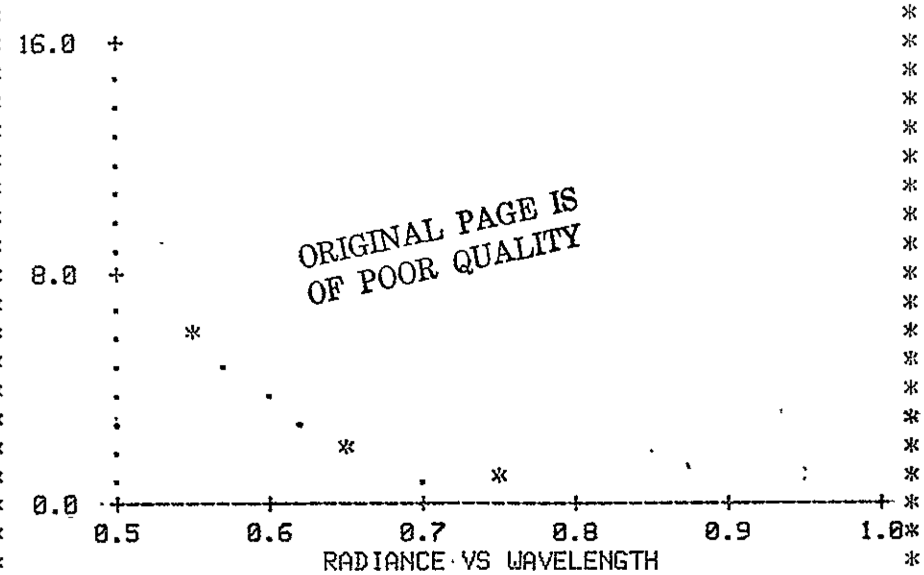
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.54	0.13	.5 - .6
BAND 5	2.28	0.12	.6 - .7
BAND 6	0.83	0.17	.7 - .8
BAND 7	0.13	0.05	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.000	-0.485	0.354
BAND 5	0.000	1.000	-0.143	-0.583
BAND 6	-0.485	-0.143	1.000	-0.086
BAND 7	0.354	-0.583	-0.086	1.000

TVI6= 0.188 TVI7= 0.624
5/4= 0.410 7/4= 0.024 7/5= 0.058



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DATA ANALYSIS LABORATORY 07/11/77

Fig. 15s. Site Processing Report, Sta. 44, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: MOT7 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

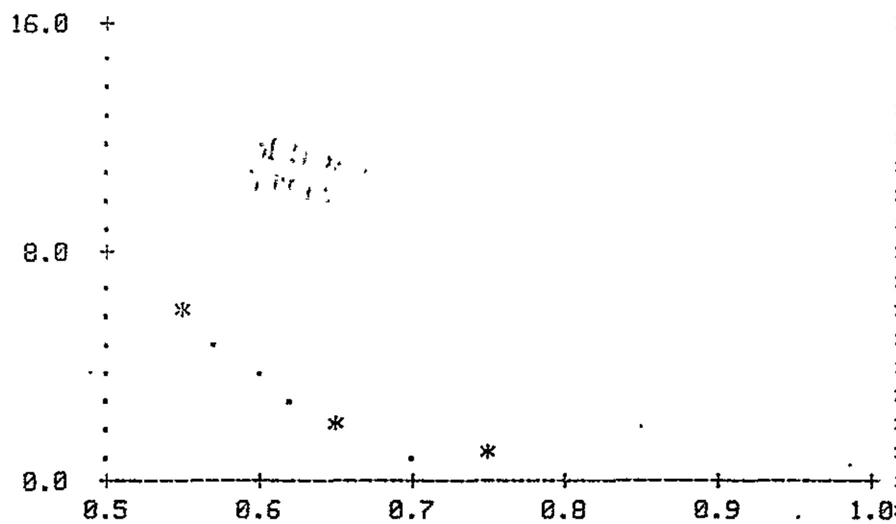
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	6.25	0.22	.5 - .6
BAND 5	2.35	0.11	.6 - .7
BAND 6	0.95	0.09	.7 - .8
BAND 7	0.12	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.025	-0.113	0.675
BAND 5	-0.025	1.000	-0.280	-0.334
BAND 6	-0.113	-0.280	1.000	-0.598
BAND 7	0.675	-0.334	-0.598	1.000

TVI6= 0.273 TVI7= 0.637
5/4= 0.376 7/4= 0.019 7/5= 0.049



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig.15t. Site Processing Report, Sta. 45, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: FDN1 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

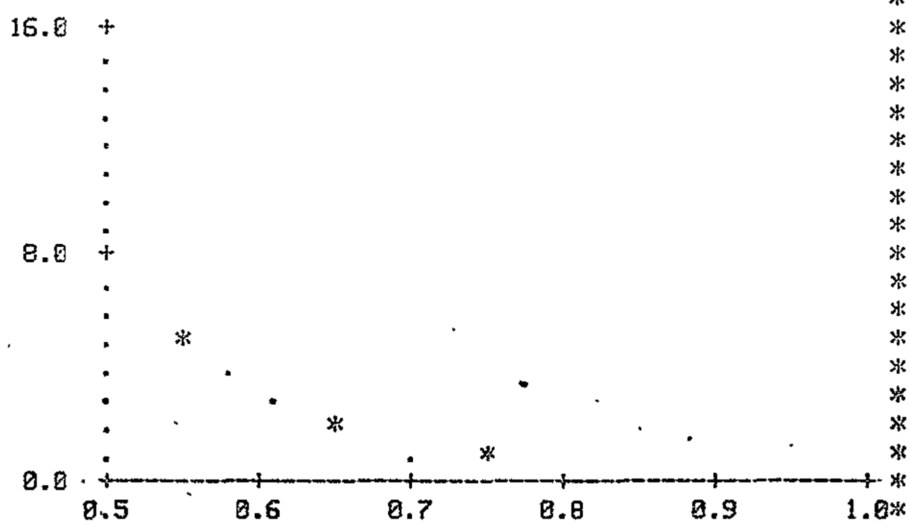
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.03	0.22	.5 - .6
BAND 5	2.27	0.13	.6 - .7
BAND 6	0.83	0.12	.7 - .8
BAND 7	0.15	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.017	-0.099	-0.432
BAND 5	0.017	1.000	0.443	-0.431
BAND 6	-0.099	0.443	1.000	0.375
BAND 7	-0.432	-0.431	0.375	1.000

TVI6= 0.192 TVI7= 0.614
5/4= 0.451 7/4= 0.030 7/5= 0.066



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig.15u. Site Processing Report, Sta. 46, March 26, 1976.

SITE PROCESSING REPORT

LANDSAT-2 342-14543

SITE DESIGNATOR: FDN2 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

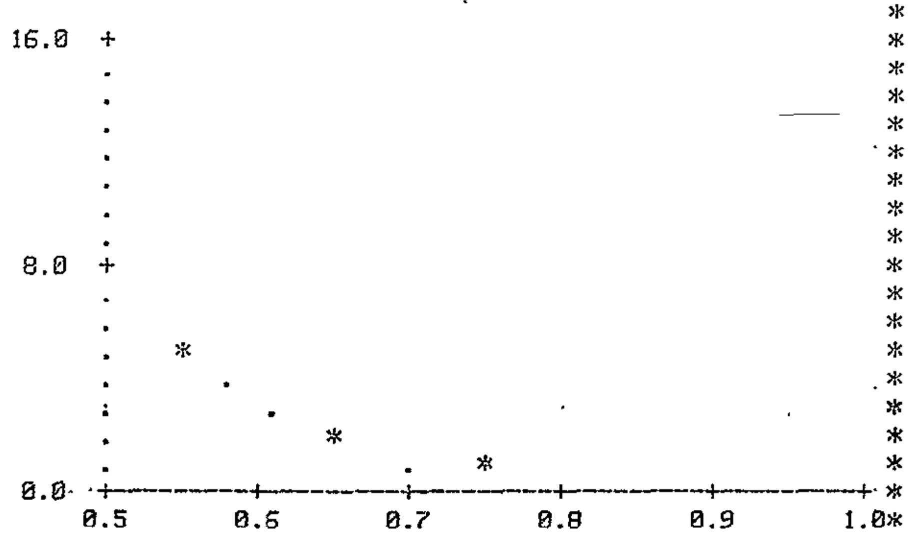
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.09	0.16	.5 - .6
BAND 5	2.26	0.09	.6 - .7
BAND 6	0.81	0.12	.7 - .8
BAND 7	0.08	0.08	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.612	-0.141	0.032
BAND 5	-0.612	1.000	0.365	0.163
BAND 6	-0.141	0.365	1.000	0.224
BAND 7	0.032	0.163	0.224	1.000

TVI6= 0.171 TVI7= 0.655

5/4= 0.444 7/4= 0.016 7/5= 0.037



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig. 15v. Site Processing Report, Sta. 47, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: FDN3 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

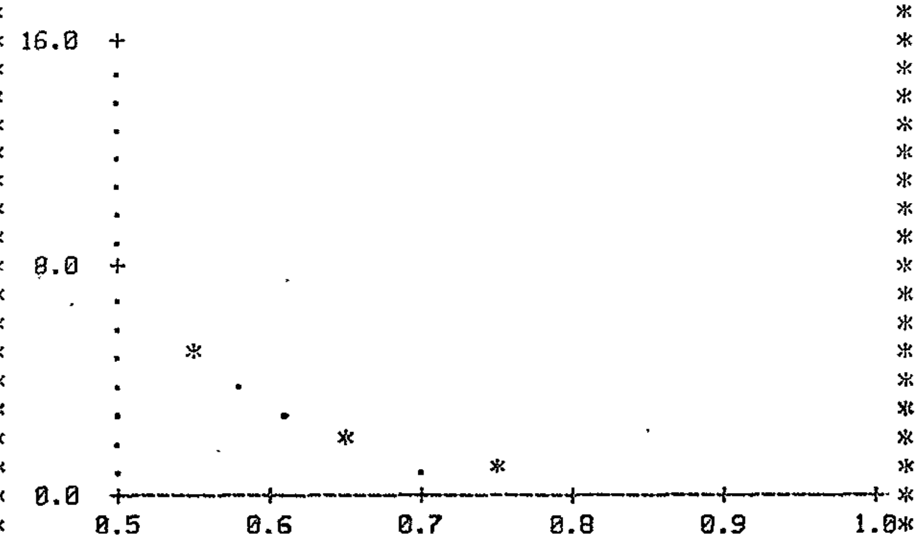
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.25	0.14	.5 - .6
BAND 5	2.25	0.07	.6 - .7
BAND 6	0.83	0.12	.7 - .8
BAND 7	0.05	0.07	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.455	-0.450	-0.113
BAND 5	-0.455	1.000	0.577	-0.289
BAND 6	-0.450	0.577	1.000	0.250
BAND 7	-0.113	-0.289	0.250	1.000

TVI6= 0.200 TVI7= 0.676
5/4= 0.429 7/4= 0.009 7/5= 0.022



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig. 15w. Site Processing Report, Sta. 48, March 26, 1976.

* SITE PROCESSING REPORT *

* LANDSAT-2 342-14543 *

SITE DESIGNATOR: FDN4 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 43 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

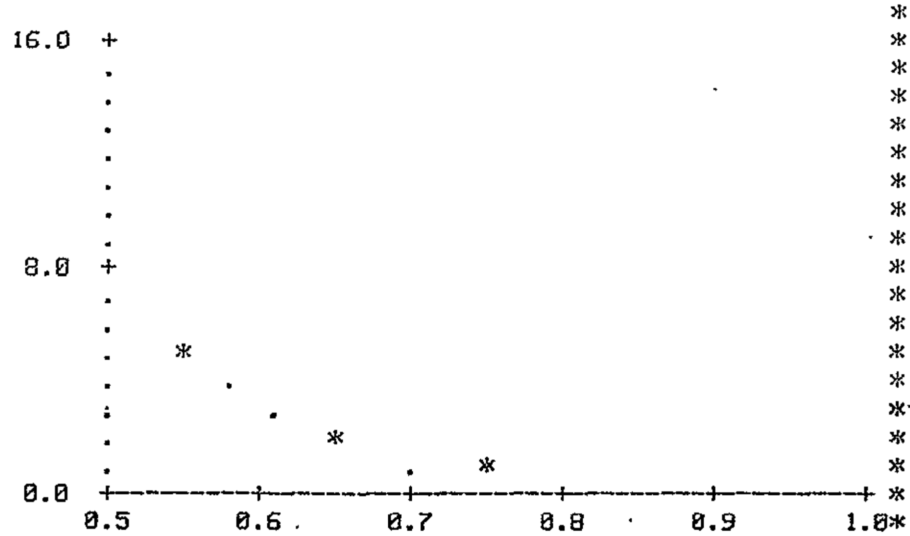
	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.42	0.20	.5 - .6
BAND 5	2.28	0.09	.6 - .7
BAND 6	0.99	0.09	.7 - .8
BAND 7	0.08	0.11	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.144	-0.118	0.649
BAND 5	0.144	1.000	-0.204	-0.187
BAND 6	-0.118	-0.204	1.000	-0.459
BAND 7	0.649	-0.187	-0.459	1.000

TVI6= 0.324 TVI7= 0.655

5/4= 0.420 7/4= 0.015 7/5= 0.036



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 07/11/77

Fig.15x. Site Processing Report, Sta. 49, March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 342-14543 ***

SITE DESIGNATOR: FDN5 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 03/26/76 TOTAL POINTS 9

CORRECTED FOR SUN. ELEVATION 43 DEGREES*

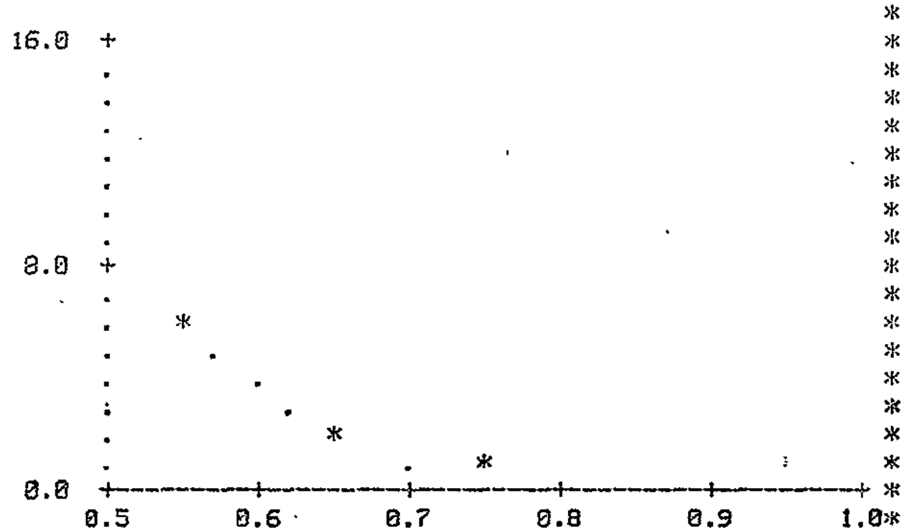
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	5.98	0.17	.5 - .6
BAND 5	2.28	0.11	.6 - .7
BAND 6	0.93	0.12	.7 - .8
BAND 7	0.12	0.10	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.085	0.535	0.083
BAND 5	0.085	1.000	0.199	0.450
BAND 6	0.535	0.199	1.000	0.177
BAND 7	0.083	0.450	0.177	1.000

TVI6= 0.280 TVI7= 0.635
5/4= 0.382 7/4= 0.019 7/5= 0.051



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 07/11/77

Fig. 15y. Site Processing Report, Sta. 50, March 26, 1976.

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*****************************************************************
*                   ****************************                *
*                   * SITE PROCESSING REPORT *                  *
*                   *  LANDSAT-2  342-14543  *                  *
*                   ****************************                *
*                                                               *
*  SITE DESIGNATOR:  FDN6  7     TOTAL AREA    10.4  ACRES      *
*  DATE AQUIRED:     033/266/       TOTAL POINTS      9         *
*                                                               *
*    **CORRECTED FOR SUN ELEVATION    43  DEGREES***            *
*                                                               *
*          RADIANCE(MWATTS/SQCM-STR-MICROMETER)                 *
*                                                               *
*                     MEAN    STANDARD   WAVELENGTH             *
*                             DEVIATION  (MICROMETERS)          *
*        BAND 4       7.13      0.20       .5 - .6              *
*        BAND 5       2.61      0.12       .6 - .7              *
*        BAND 6       0.85      0.14       .7 - .8              *
*        BAND 7       0.03      0.07       .8 -1.1              *
*                                                               *
*                   NORMALIZED COVARIANCES                      *
*                    BAND 4    BAND 5    BAND 6    BAND 7       *
*        BAND 4       1.000    -0.037     0.151     0.000       *
*        BAND 5      -0.037     1.000     0.303     0.000       *
*        BAND 6       0.151     0.303     1.000    -0.645       *
*        BAND 7       0.000     0.000    -0.645     1.000       *
*                                                               *
*                   TVI6= 0.088      TVI7= 0.689                *
*          5/4= 0.366     7/4= 0.005     7/5= 0.013             *
*                                                               *
* 16.0  +                                                       *
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*  8.0  +                                                       *
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*       .                   .                                   *
*       .                        *                              *
*  0.0  +---------+---------+---------+---------+---------+     *
*      0.5       0.6       0.7       0.8       0.9       1.0    *
*                    RADIANCE VS WAVELENGTH                     *
*                                                               *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER      *
*            DATA ANALYSIS LABORATORY  6 07/11/                 *
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Fig. 15z. Site Processing Report, Sta. 51,
March 26, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 546-15152 ***

SITE DESIGNATOR: TMP1 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 06/21/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES*

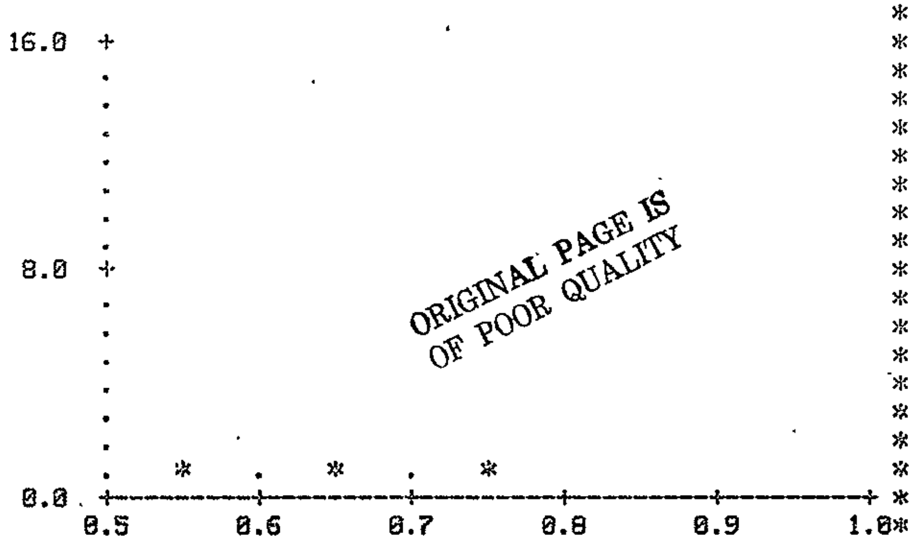
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.20	0.08	.5 - .6
BAND 5	0.71	0.03	.6 - .7
BAND 6	1.07	0.12	.7 - .8
BAND 7	0.10	0.14	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.250	0.459	0.500
BAND 5	-0.250	1.000	-0.115	0.500
BAND 6	0.459	-0.115	1.000	0.229
BAND 7	0.500	0.500	0.229	1.000

TVI6= 0.836 TVI7= 0.513
5/4= 0.597 7/4= 0.080 7/5= 0.134



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 05/10/77

Fig. 15*i*. Site Processing Report, Sta. 32, July 21, 1976.

*** SITE PROCESSING REPORT ***

*** LANDSAT-2 546-15152 ***

SITE DESIGNATOR: TMP2 7   TOTAL AREA 10.4 ACRES

DATE AQUIRED: 06/21/76   TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.20	0.08	.5 - .6
BAND 5	0.65	0.05	.6 - .7
BAND 6	0.85	0.17	.7 - .8
BAND 7	0.03	0.10	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.144	0.316	0.250
BAND 5	0.144	1.000	0.091	-0.144
BAND 6	0.316	0.091	1.000	0.316
BAND 7	0.250	-0.144	0.316	1.000

TVI6= 0.794   TVI7= 0.637

5/4= 0.544   7/4= 0.027   7/5= 0.049

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16.0 +
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     .
     .
     .
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     .
     .
 8.0 +
     .
     .
     .
     .
     .
     .
     .    *    .    *    .    *
 0.0 +---------+---------+---------+---------+---------+
    0.5       0.6       0.7       0.8       0.9       1.0
                  RADIANCE VS WAVELENGTH
```

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER

DATA ANALYSIS LABORATORY 05/10/77

Fig.15*ii*. Site Processing Report, Sta. 33, July 21, 1976.

*** SITE PROCESSING REPORT ***

*** LANDSAT-2 546-15152 ***

SITE DESIGNATOR: TMP3 7 TOTAL AREA 10.4 ACRES

DATE AQUIRED: 06/21/77 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.18	0.07	.5 - .6
BAND 5	0.66	0.03	.6 - .7
BAND 6	0.96	0.07	.7 - .8
BAND 7	0.16	0.15	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	0.142	-0.238	-0.142
BAND 5	0.142	1.000	-0.060	-1.000
BAND 6	-0.238	-0.060	1.000	0.060
BAND 7	-0.142	-1.000	0.060	1.000

TVI6= 0.828 TVI7= 0.330

5/4= 0.558 7/4= 0.136 7/5= 0.243

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16.0  +
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      .
 8.0  +
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      .
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      .
      .
      .    *    .    *    .    *
 0.0  +---------+---------+---------+---------+---------+
     0.5       0.6       0.7       0.8       0.9       1.0
                   RADIANCE VS WAVELENGTH
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ORIGINAL PAGE IS OF POOR QUALITY

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 05/10/77

Fig. 15*iii*. Site Processing Report, Sta. 34, July 21, 1976.

SITE PROCESSING REPORT
LANDSAT-2 546-15152

SITE DESIGNATOR: TMP4 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 06/21/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES*

RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.20	0.08	.5 - .6
BAND 5	0.64	0.04	.6 - .7
BAND 6	0.87	0.26	.7 - .8
BAND 7	0.03	0.10	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.500	0.426	0.250
BAND 5	-0.500	1.000	-0.293	-0.125
BAND 6	0.426	-0.293	1.000	0.426
BAND 7	0.250	-0.125	0.426	1.000

TVI6= 0.804 TVI7= 0.637
5/4= 0.538 7/4= 0.027 7/5= 0.050

```
16.0  +
      .
      .
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      .
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      .
 8.0  +
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      .
      .
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      .
      .
      .    *    .    *    .    *
 0.0  +---------+---------+---------+---------+---------+
     0.5       0.6       0.7       0.8       0.9       1.0
                  RADIANCE VS WAVELENGTH
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PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 05/10/77

Fig.15*iv*. Site Processing Report, Sta. 35, July 21, 1976.

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*                 ***************************                     *
*                 * SITE PROCESSING REPORT *                      *
*                 *  LANDSAT-2  546-15152  *                      *
*                 ***************************                     *
*                                                                 *
*  SITE DESIGNATOR:  WATR  7     TOTAL AREA    10.4  ACRES        *
*  DATE AQUIRED:     07/21/76       TOTAL POINTS      9           *
*                                                                 *
*    **CORRECTED FOR SUN ELEVATION    56  DEGREES***              *
*                                                                 *
*          RADIANCE(MWATTS/SQCM-STR-MICROMETER)                   *
*                                                                 *
*                   MEAN     STANDARD   WAVELENGTH                *
*                            DEVIATION  (MICROMETERS)             *
*        BAND 4     1.18       0.05      .5 - .6                  *
*        BAND 5     0.67       0.04      .6 - .7                  *
*        BAND 6     0.90       0.15      .7 - .8                  *
*        BAND 7     0.06       0.13      .8 -1.1                  *
*                                                                 *
*                 NORMALIZED COVARIANCES                          *
*                  BAND 4    BAND 5    BAND 6    BAND 7           *
*        BAND 4     1.000     0.392     0.131    -0.577           *
*        BAND 5     0.392     1.000    -0.334    -0.134           *
*        BAND 6     0.131    -0.334     1.000     0.357           *
*        BAND 7    -0.577    -0.134     0.357     1.000           *
*                                                                 *
*                 TVI6= 0.804      TVI7= 0.571                    *
*          5/4= 0.570      7/4= 0.054      7/5= 0.095             *
*                                                                 *
* 16.0  +                                                         *
*       .                                                         *
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*  8.0  +                                                         *
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*       .                                                         *
*       .                                                         *
*       .                                                         *
*       .    *     .    *     .    *                              *
*  0.0  +---------+---------+---------+---------+---------+       *
*      0.5       0.6       0.7       0.8       0.9       1.0      *
*                    RADIANCE VS WAVELENGTH                       *
*                                                                 *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER        *
*             DATA ANALYSIS LABORATORY  05/13/77                  *
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Fig. 15v. Site Processing Report, Sta. 36, July 21, 1976.

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*                  **************************                  *
*                  * SITE PROCESSING REPORT *                  *
*                  *  LANDSAT-2  546-15152  *                  *
*                  **************************                  *
*                                                               *
*  SITE DESIGNATOR:   TMP6  7     TOTAL AREA    10.4  ACRES    *
*  DATE AQUIRED:      07/21/76       TOTAL POINTS       9      *
*                                                               *
*    **CORRECTED FOR SUN ELEVATION    56  DEGREES***            *
*                                                               *
*          RADIANCE(MWATTS/SQCM-STR-MICROMETER)                 *
*                                                               *
*                  MEAN     STANDARD   WAVELENGTH               *
*                           DEVIATION  (MICROMETERS)            *
*        BAND 4    1.24       0.05       .5 - .6                *
*        BAND 5    0.72       0.05       .6 - .7                *
*        BAND 6    0.94       0.12       .7 - .8                *
*        BAND 7    0.16       0.15       .8 -1.1                *
*                                                               *
*                NORMALIZED COVARIANCES                         *
*                 BAND 4    BAND 5    BAND 6    BAND 7          *
*        BAND 4   1.000     0.414    -0.392     0.219           *
*        BAND 5   0.414     1.000    -0.162    -0.073           *
*        BAND 6  -0.392    -0.162     1.000    -0.447           *
*        BAND 7   0.219    -0.073    -0.447     1.000           *
*                                                               *
*                TVI6= 0.794     TVI7= 0.370                    *
*          5/4= 0.581     7/4= 0.129     7/5= 0.222             *
*                                                               *
* 16.0  +                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*  8.0  +                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .                                                       *
*       .    *    .    *    .    *                              *
*  0.0  +---------+---------+---------+---------+---------+     *
*      0.5       0.6       0.7       0.8       0.9       1.0    *
*                  RADIANCE VS WAVELENGTH                       *
*                                                               *
*  PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER      *
*             DATA ANALYSIS LABORATORY  05/13/77                *
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Fig. 15*vi*. Site Processing Report, Sta. 37,
July 21, 1976.

*** SITE PROCESSING REPORT ***
*** LANDSAT-2 546-15152 ***

SITE DESIGNATOR: TMP7 7 TOTAL AREA 10.4 ACRES
DATE AQUIRED: 07/21/76 TOTAL POINTS 9

CORRECTED FOR SUN ELEVATION 56 DEGREES

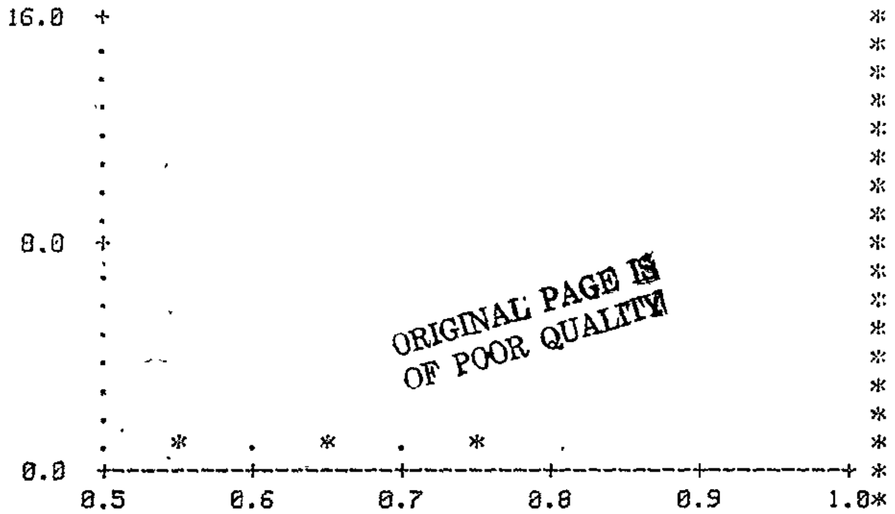
RADIANCE(MWATTS/SQCM-STR-MICROMETER)

	MEAN	STANDARD DEVIATION	WAVELENGTH (MICROMETERS)
BAND 4	1.16	0.03	.5 - .6
BAND 5	0.66	0.03	.6 - .7
BAND 6	0.92	0.09	.7 - .8
BAND 7	0.00	0.00	.8 -1.1

NORMALIZED COVARIANCES

	BAND 4	BAND 5	BAND 6	BAND 7
BAND 4	1.000	-0.395	-0.316	0.000
BAND 5	-0.395	1.000	0.800	0.000
BAND 6	-0.316	0.800	1.000	0.000
BAND 7	0.000	0.000	0.000	0.000

TVI6= 0.816 TVI7= 0.707
5/4= 0.566 7/4= 0.000 7/5= 0.000



RADIANCE VS WAVELENGTH

PREPARED BY: TEXAS A&M UNIVERSITY REMOTE SENSING CENTER
DATA ANALYSIS LABORATORY 03/13/77

Fig. 15*vii*. Site Processing Report, Sta. 38, July 21, 1976.

The REMOTE SENSING CENTER was established by authority of the Board of Directors of the Texas A&M University System on February 27, 1968. The CENTER is a consortium of four colleges of the University; Agriculture, Engineering, Geosciences, and Science. This unique organization concentrates on the development and utilization of remote sensing techniques and technology for a broad range of applications to the betterment of mankind.